CONCRETE SILOS

Their Advantages
Different Types
How to Build Them

By

E. S. HANSON

Affiliated Member Western Society of Engineers, Editor THE CEMENT ERA. Author "Cement Pipe and Tile," "Concrete Roads and Pavements," Etc.

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PREFACE.

In this volume the author has attempted to bring together everything of value pertaining to the latest concrete silo construction. His investigation of the subject has led him to believe that there is a demand for such a book. While there is a large mass of literature on concrete silos extant, practically every piece of such printed matter is prepared with special emphasis on some particular type of construction, or on some particular phase of the subject.

This volume is an attempt to bring together all the best things in this scattered literature, making it, so far as possible, a complete compendium of concrete silo construction. For this purpose the author has drawn freely upon bulletins of the various cement companies and of the Association of American Portland Cement Manufacturers, as well as upon publications of the State Agricultural Experimental Stations, and the literature of the companies promoting various patented systems.

The demand for the book, even before it has appeared from the press, has been so gratifying that it is expected another edition will be necessary at an early date. The author will therefore be pleased to have readers advise him of any errors, inaccuracies, or omissions which they find.

E. S. HANSON.

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CHAPTER I

WHY BUILD A SILO?

The silo is not a fad. It has proven its right to a place in any intelligent scheme of agricultural economics, and it has therefore come to stay.

Coming first into existence as a mere hole in the ground, the silo has developed into a structure on which it is worth while to expend engineering ability and architectural skill. Many things have been attributed to Cæsar and his strategists as the result of military necessity in the prosecution of his famous campaigns. Some of these are recorded in his own Commentaries, while others have perhaps a less stable historical foundation on which to rest. Our reading of the Seven Books is too far in the past to allow of a definite statement as to whether the famous general himself records the use of pit silos for the preservation of forage along his lines of march; but such have been attributed to him, and the statement sounds plausible, at any rate.

The silo has been likened to a giant fruit jar. Apparently this idea, too, is not a new one, for it is stated that the early Egyptians, many years before the Christian era, put a part of their crops in large stone jars for preservation, covering them as tightly as possible to exclude the air. The Mound Builders and other prehistoric tribes adopted similar expedients, as is proven by the relics which are unearthed from time to time, while some of the barbaric tribes of the present day build circular bins of interwoven reeds and plaster them on both sides with clay, with a thatched roof for a cover.

The following reasons for the popularity of silage are given by T. E. Woodward, of the Dairy Division of the U. S. Department of Agriculture:

(1) Silage is the best and cheapest form in which a succulent feed can be provided for winter use.

(2) An acre of corn can be placed in the silo at a cost not exceeding that of shocking, husking, grinding and shredding.

(3) Crops can be put into the silo during weather that could not be utilized in making hay or curing fodder; in some localities this is an important consideration.

(4) A given amount of corn in the form of silage will produce more milk than the same amount when shocked and dried.

(5) There is less waste in feeding silage than in feeding fodder. Good silage properly fed is all consumed.

(6) Silage is very palatable.

(7) Silage, like other succulent feeds, has a beneficial effect upon the digestive organs.

(8) More stock can be kept on a given area of land when silage is the basis of the ration.

(9) On account of the smaller cost for labor, silage can be used for supplementing pastures more economically than can soiling crops, unless only a small amount of supplementary feed is required.

(10) Converting the corn crop into silage clears the land and leaves it ready for another crop sooner than if the corn is shocked and husked.

Another and even longer list of advantages of ensilage is given by the experts of the Missouri Agricultural Experiment Station. They are as follows:

(1) Harvesting corn as silage saves from 35 to 40 per cent of the crop that would otherwise be wasted.

(2) Silage adds palatableness to the ration.

(3) Silage adds succulency to the ration.

(4) Silage serves to keep the digestive tracts of animals in good condition.

(5) Silage replaces high-priced hay.

(6) Silage serves to cheapen the ration.

(7) When silage is fed, more feed is eaten, hence more manure.

(8) The man who feeds silage uses a manure spreader.

(9) The feeding of silage means more intelligence in feeding operations.

(10) The feeding of silage results in more intelligence in other farm operations.

(11) The man who feeds silage will feed with it concentrates rich in protein, and leguminous hay of some kind. Hence, not only more manure, but a better quality.

(12) The man who feeds concentrates and leguminous hays with silage is apt to try to grow legumes in the rotation. Hence, a better and more productive soil.

(13) Silage is a good feed for the general farmer.

(14) Silage is a good feed for dairy cows.

(15) Beef can be produced more economically when silage forms a part of the ration.

(16) Silage is a good feed for calves and stocker cattle.

(17) Silage is a good feed for breeding cattle.

(18) Silage is a good feed for fattening lambs.

(19) Silage is a good feed as a part ration for brood ewes if fed intelligently.

(20) Silage can be fed successfully as a part ration to mules.

(21) Silage can be fed successfully as a part ration for horses.

(22) Silage may be fed as a conditioner to swine in general, and as a part ration to old brood sows.

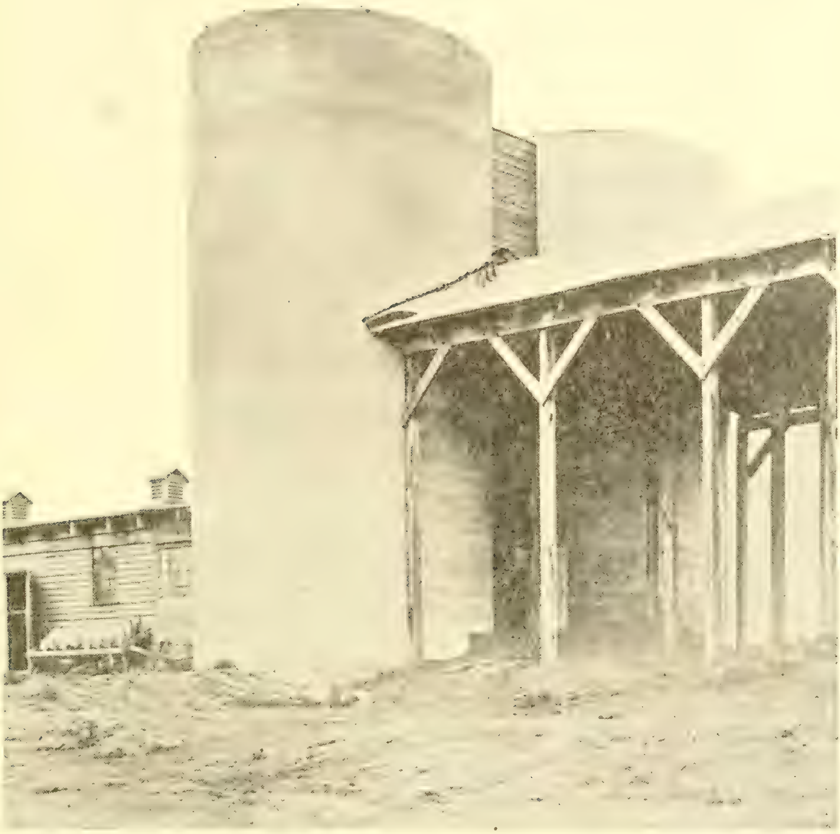
(23) Silage mixed with wheat and potatoes, equal parts, and boiled in water makes a good ration for poultry.

(24) Silage takes up less room in storage than either hay or corn fodder.

As to the kind of crops which can be preserved in the silo to advantage, it has been stated that anything which does not have a hollow stem will make good silage. This statement has a reasonable measure of truth. The reason that crops with hollow stems have been excluded is, that it is impossible to get the air pressed out of the stems, and on account of the presence of this air, decomposition is sure to take place.

The fact remains, however, that corn is pre-eminently the crop for the silo. As stated by Prof. C. H. Eckles, of the Missouri Experiment Station, and borne out by the statements of many other authorities, the total yield of nutrients per acre with this crop is greater than ordinarily secured from any other. It has the further advantage of packing well to exclude the air, and contains the proper amount of sugar to form acids needed to preserve without becoming sour.

An acre of corn as silage requires much less room for storage than an acre of corn harvested in any other way. When the harvesting is done the work is mainly over. The field is left clear for any fall sowing. Drilled corn yielding 75 bushels to the acre, when cut and shocked, eleven shocks to the acre, covers about 3 per cent of the area of the field. The shocks remain in the way of the next crop. Before the corn is husked out, bad, rainy, snowy weather often comes. The stalks,



Two of the Four Silos on the Dairy Farm of Thomas A. Edison, at Stewartsville, N. J.

blades and shuck become so damaged from the weather that they are not worth much as a feed, even if they were always fed in a dry, clean place where stock could not tramp them into the ground in wet, muddy weather. The process of husking, throwing the corn on the ground, pitching it into a wagon and out again, and then out of the crib into the same wagon before it can be fed, is not only an expensive one, making the farm labor problem still harder to solve, but it is a wasteful one. Much corn damages from the weather, from rats and mice and from shelling in handling so many times.

It costs on an average about 12½ cents to put corn into the shock and about 12½ cents to shuck it out. The stover (stalk without the ear), sells on the average for about 12½ cents a shock. This is an expensive operation, even when it is the last resort, but on some farms it is a common practice.

However, when a man has no silo in which to harvest corn and his crop rotation is such that corn is to be followed by wheat, or some other fall sowing, about the only thing he can do is to cut the corn and put it into the shock. This is especially true if a man is a grain farmer and cannot forage the corn off.

Again it may be stated that while silage can be fed to practically all farm animals to good advantage, it is pre-eminently the ideal ration for cattle, and especially the dairy cow. It thus forms an important link in connecting up one of our largest farm crops with the wide-spread and important industry of cattle raising and dairying.

The digestive organs of animals that chew the cud are so formed as to require comparatively juicy and bulky food. The cow cannot, therefore, thrive on exclusively dry food so well as can the horse. The nearest an ideal food that can be obtained for the dairy cow is good pasture; but for more than six months in the year green pasture is not available in large sections of this country. The best substitutes to use during this period are corn silage and such roots as mangels and turnips. Corn yields an average of twice as much dry matter per acre as do root crops, and, since the latter require much more labor, which in this country is relatively expensive, silage is far more economical.

The dairy cow has been likened unto a factory—a factory for the production of milk and butter. She eats her feed, converts it into blood and from the blood which passes through the mammary gland or udder, she extracts the milk. The output of this factory, like that of any other factory, depends much upon the amount and quality of raw material consumed. No cow can produce a large quantity of milk and butter unless she has the capacity and consumes a large quantity of good feed. Since it is impossible to feed fat into milk or change the average per cent of butter fat in a cow's milk by the kind, amount or quality of feed, the thing for us to do is to feed her in such a way as to enable her to produce the maximum amount of milk. From more milk we can get more butter fat.

In order to get a cow to consume large quantities of feed, the feed must be good and palatable. Palatableness means much. Every feeder of live stock of any kind recognizes the importance of keeping the appetites of animals good.

During the process of fermentation of silage in the silo, the corn plant is rendered more digestible and more palatable than dry shock corn, and a flavor very acceptable to dairy cows is produced. After cows have been fed silage, they will stretch out their backs and turn their heads in the direction of the feeder the minute he starts toward them with a box of silage. So well do cows relish silage, they will eat more of it than they do of dry fodder or even of green corn. This is a point in favor of silage, because every cow must eat so much feed for the daily maintenance of her body. After this maintenance requirement is met, all excess food can be used for the production of milk and butter. However, some cows do not make use of this excess food in this way. They use it for surplus fat and flesh, thereby gaining in weight. The chief difference between dairy cows is shown in the difference in the disposition that they make of their food over and above that required for maintenance. Now, if every cow would absolutely refuse to produce a drop of milk until after her daily body maintenance requirements were met, some of us would learn a little faster how to feed for milk production. But not every, or even any cow, makes this demand. There are three classes of cows when both cows and the feed they are given are considered:

Class 1. Cows that receive more than a maintenance ration and use the excess for the production of milk and butter.

Class 2. Cows that receive more than a maintenance ration and use the excess for the production of surplus flesh and fat, storing it away on their bodies, growing heavier every day.

Class 3. Cows that receive less than a maintenance ration and have to draw upon the food nutrients already stored on their bodies in order to keep up a flow of milk, thus growing thinner and thinner in flesh every day.

This third or last named class is seldom found in the herd of the man who feeds silage. He feeds as a rule an abundance of palatable, succulent silage in combination with other feeds richer in protein content. The protein in the ration goes to make bone, muscle and the curd in the milk.

Silage is a roughage. Ruminants require a greater per cent of roughage in the ration than do other classes of animals. Corn silage comes the nearest to having all of the properties of good green grass of any of the feeds we have. We can have it in the winter time, too, when grass is gone and other feeds are dry. We can have it in the summer time when the grass is short in dry periods of drought. Silage, above all other feeds, enables the dairyman to maintain almost unbroken summer conditions, conditions under which the maximum amount of milk and butter is produced.

A feed containing a large amount of water in the form of natural plant juices is not only more easily digested, but is also more palatable and, besides, serves the useful purpose of keeping the whole system of the animal in good condition. A silage-fed animal is rarely troubled with constipation or other digestive disturbances, the coat is noticeably sleek and soft, and the skin is soft and pliable.

No rough feed is more palatable than good corn silage. Sometimes, however, a cow will not eat silage readily until she has acquired a taste for it; this may require several days. But silage is not peculiar in this respect, for it has been observed that range horses or cattle shipped into the corn belt refuse corn the first time it is offered to them. The quality of palatability is of great importance, as it induces a large consumption and stimulates the secretion of digestive juices.

The advantage of silage in the dairy industry was at one time put into a forcible statement by W. B. Barney, state dairy commissioner of Iowa. Among other things he said:

The dairy cow is the most economical producer of human food on the farm if fed and cared for in an intelligent manner. The milk of a cow that produces 10,000 pounds yearly contains 8,710 pounds of water, 290 pounds of fat, 485 pounds of sugar, 340 pounds of protein and 75 pounds of ash. Therefore, it is evident that the cow must consume large quantities of succulent feed to produce milk economically. The grass in summer provides her with such feed, but if the farmer is without a silo his cows are deprived of succulent feed for winter use. No man keeping six or more cows can afford to be without a silo, regardless of its first cost.

Today the silo is no longer an experiment, and practically all the leading dairymen of the country are using them. Some seven or eight thousand new silos have been built in Iowa alone during the past year, which is sufficient evidence that they are a success. We are not suffering today in the rural districts for the want of finding new things so much as we are for the simple application of the things we already know. Practically every farmer admits that the silo is a good thing, but he puts off until tomorrow what he should do today, and the waste of crop continues from year to year. In the corn belt where stalks are allowed to stand in the field, 40 per cent of the crop is wasted. It has been estimated that an acre of corn put up in a silo has a value of $45, while the same standing in the field and husked has a value of $27. Thus it can be seen that the silo nearly doubles the value of the corn crop.

In feeding silage with alfalfa or clover hay we have practically a balanced ration all raised on the farm. Experiments have been conducted at the Kansas and other stations which show that the grain ration can be cut down one-half the usual amount where alfalfa or clover hay and silage are fed. Silage always plays a prominent part in the economical ration of most farm animals, and may the day be not far distant when the silo will be as common a sight on the Iowa farm as the corn crib is today.

In the Central West corn is hailed as the king of all cereals, forming the backbone of the rations of the majority of our farm animals. By placing corn in the silo the stalk as well as the ear is preserved, thus making the whole corn plant available for feeding purposes. Practically 40 per cent of the feeding value of the corn plant lies in the stalk, leaves and husks, the remainder in the ear. Therefore, if only the ears are gathered, much of the remaining 40 per cent of the crop remains in the field to bother the farmer in preparing his seedbed for the following year. As corn should be cut for the silo before the lower leaves are lost there is practically no waste. About twice the amount of dry matter can be stored in the form of silage as corn fodder. A cubic foot of hay in the mow contains about 4.3 pounds of dry matter, while a cubic foot of silage contains 8.9 pounds of dry matter. A cubic foot of space in the silo is, therefore, worth more than twice an equal space in the mow.

The digestive organs of animals that chew their cud are so formed as to require comparatively juicy and bulky feeds. The cow cannot thrive on dry feed as well as the horse. The ideal food for the dairy cow is green pasture, but for a number of months during the year she is deprived of this feed. The best substitutions for green pasture are root crops and corn silage. As silage yields twice as much dry matter per acre as roots and does not require as much labor, silage is by far the more economical wherever corn can be raised. Silage has a laxative effect upon the animal and aids in maintaining a healthy and vigorous condition.

The population of the United States is doubling every thirty years, which means that the farms will gradually become smaller and that more feed must be produced per acre. The high price of land also demands that more intensive methods must be used to obtain a dividend in proportion to the value of the soil. Practice tells us that one acre of corn placed in the silo will yield enough feed to supply a milk cow 40 pounds of silage for 500 days or 4 cows 125 days.

Another important factor is the reduction in storage space of silage compared to that required for hay.

One ton of clover hay occupies 400 cubic feet, while 8 tons of silage can be placed in the same space. The clover hay contains 886 pounds of digestible nutrients, while the silage contains 2,064 pounds. Thus the corn silage occupying the same space as the clover hay contains two and a half times the digestible nutrients.

Silage as a milk producer compares very favorably with the other more concentrated and more expensive feeds. Being a very succulent and palatable feed, it can be very aptly termed the great substitute for pasture in the corn belt. We all look forward to the increased milk flow when the cows are turned to pasture in the spring after having received nothing but dry feed for six months. The milk cow is a sensitive animal at hard work and should be nurtured on the best feed possible. Silage makes possible a succulent feed for winter use, spurring the appetite of the cow and causing her to relish her feed in winter as well as summer.

Several years ago at the Ohio Experiment Station the substitution of silage for grain in the ration proved very successful. Silage was used to take the place of over half the grain ration and proved to be much cheaper. The silage ration produced milk for 68 cents per 100 pounds and butter fat at the rate of 13 cents per pound. The grain ration produced milk at $1.05 per 100 pounds and butter fat for 22 cents per pound. This made the profit from the silage ration $5.86 per month, and of the grain ration $2.46 per month.

There is an occasional suggestion that milk from silage fed cows has a disagreeable flavor. In order to determine what foundation, if any, there was for this belief, a series of experiments was sometime ago undertaken by the Agricultural Experimental Station of the University of Illinois.

For the purpose of these experiments, the University dairy herd was divided into two lots, one of which was fed 40 pounds of corn silage per cow per day, together with a small amount of clover hay and grain. The feed for the other lot consisted entirely of clover hay and grain. The milk from both the lots was cared for in exactly the same manner and was standardized to 4 per cent of butter fat in order that there might be no difference in the flavor of the two lots of milk on account of the variation in this respect.

The people whose tastes were consulted with regard to the milk were divided into three classes: ladies, men of the faculty, and students.

In one case the silage had been fed one hour before milking. Of the 29 ladies who sampled this milk, 10 preferred the silage milk, 14 the non-silage, and 5 had no choice. Of the men of the faculty, 27 preferred the silage milk, 20 the non-silage, and 7 had no choice. Of the students, 20 preferred the silage milk, 4 non-silage, and 4 had no choice.

A preference for silage milk was indicated by 51 per cent of the 111 tests made when silage was fed one hour before milking. When silage was fed at time of milking, 71 per cent preferred silage milk, and when fed after milking 51 per cent reported the same preference. Of the total tests, amounting to 372 persons, 223 preferred silage milk, 109 non-silage milk and 40 had no choice.

In making an investigation of the entire silo question, *The Twentieth Century Farmer,* of Omaha, says that it found one man who, although having three silos on his place, claimed that silage was too expensive a feed for profitable use, and that he would not recommend other farmers to erect silos. He told the investigator that alfalfa was a much better and cheaper feed and he believed better results could be obtained by feeding more alfalfa and less silage. He was discovered, however, plowing up an alfalfa patch, putting in some corn, and not feeding any new alfalfa that season. This resulted in an investigation, which seemed to show that the man's statements were prompted by selfish motives, rather than by his real feeling in the case. It was found that he had bought up during the winter, from his neighbors who did not have silos, and were thus compelled to sell, a lot of calves and young cattle, feeding them on the silage he had stored in his silos and making a very nice profit on the deal. If his neighbors were encouraged to build silos the possibility of his again taking advantage of their unfortunate circumstance would be very slight indeed.

One line of investigation followed by *The Twentieth Century Farmer* was to find out whether or not a much larger percentage of cattle could be maintained on the farms of the country by the more extended use of the silo and the feeding of silage year after year. This question was therefore asked of numerous farmers of from one to seven or eight years' experience in feeding silage, what percentage more of cattle could be kept profitably on their farms if they had sufficient silo room in which they could be sure to have silage to supplement the pastures in dry periods, and also to have plenty of this feed for winter time. While none of them had definite figures they could give, they all had some ideas based on their feeding experience. The answers to these questions from probably 50 different silo users have been that they could keep from 50 to 100 per cent more cattle by the use of the silo than they could without.

Silage stands first in rank of all the roughages for finishing cattle, says T. E. Woodward, of the U. S. Department of Agriculture. Formerly, during the era of cheap corn and other concentrates, little attention was given to the roughage, as it was usually considered merely a "filler" and of very little economic value in feeding. No especial care was taken in selecting any particular kind, nor was the quality of it seriously considered. As the prices of the concentrated feedstuffs advanced, the feeder looked about for methods of cheapening the cost of producing beef, and soon found this could be accomplished by using judgment in selecting his roughage with respect to the grain fed. This has continued until at the present time the roughage receives as much attention as the concentrated feed, and has been made to take the place of a large amount of the latter. The feeding of silage came into general use with the advent of expensive grain and is becoming more popular each year. With the present prices of feedstuffs, there is hardly a ration used for feeding cattle which cannot be cheapened by the use of this succulent feed. By combining it with other feeds, the efficiency of the ration is increased to such an extent that the amount of the daily gains is invariably greater and the cost of producing a pound of gain is lessened. The heaviest daily gains are usually made during the first stage of the feeding period, and silage can then be used to advantage in large quantities with a small amount of grain, but as the feeding progresses the amount of silage should be lessened and the grain increased. In some places the price of hay and stover is so high that the greater the proportion of silage used in the ratien the more profitable is the feeding.

Silage is a quick finishing roughage in that it produces large daily gains and produces a glossy coat and a soft, pliable skin. Moreover, it can be used to advantage at times for carrying cattle for a longer time so as to pass over a period of depression in the market, or to carry the cattle along in thrifty condition so they can be finished at a later period.

For many years the belief was general that cattle which received silage as a major portion of the roughage would have to be kept in warm barns and not exposed to the cold. While they do need protection from the cold winds and rains and need a dry place to lie down, it has been clearly demonstrated that warm barns are not only unnecessary, but that fattened cattle make both larger and cheaper gains when fed in the open sheds than when confined in barns.

Silage can be profitably used to supplement the pastures for steers during a time of drought, when they are being finished for market.

The general impression that choice or prime carcasses cannot be made by the use of succulent feed is equally untrue, as the silage-fed cattle usually make more desirable carcasses than cattle fed a similar ration except that silage was replaced by one of the coarse fodders. There is no appreciable difference in the percentage of marketable meat that steers will dress out which have been finished on a silage ration and a dry ration. The meat seems equally bright and the fat as well intermixed with the lean.

A number of the agricultural experiment stations have conducted experiments at various times to ascertain the value of silage as a rough feed. At the Missouri Station, some experiments were made with two-year-old fattening steers, under direction of Prof. H. D. Allison. Without going into the details of this experiment it will be necessary only to give a few paragraphs from the summary made by Professor Allison. He says:

A ton of silage, as used in this experiment, was approximately equal to one-half ton of clover hay.

Estimated on the basis of net profit per steer, a ton of dry matter in the form of corn silage yielded 50.3 per cent greater value than a ton of dry matter in the form of shock corn.

It is evident from the data given that it takes less grain in the form of shelled corn to fatten two-year-old steers when corn silage composes a part of the ration.

A superior finish is obtained on fattening cattle which are marketed in the spring when silage composes a part of the ration.

A similar experiment at the Iowa station brought practically the same results. Regarding it, Prof. John M. Evvard stated that "the silage-fed cattle, without a single exception, returned greater profit than when clover was fed as the only roughage. By using silage the gains in weight were cheapened and the profit per steer increased."

Some very valuable cattle feeding tests have been conducted at the Pennsylvania State Experiment Station, among them an experiment to determine to what extent silage could profitably be used in steer feeding. This experiment lasted 126 days. The results of the test are given in detail by Prof. W. A. Cochel, in Bulletin No. 118, issued by the Pennsylvania station.

The results of this experiment are interesting at this point, not only because silage formed a part of the ration used, but on account of some valuable data derived, showing that during the early part of the feeding period some ear corn or shelled corn can profitably be replaced by silage.

In his Bulletin Professor Cochel says: "Experiments at this and other stations have shown that the addition of corn silage to the rations that are usually fed to fattening animals, results in cheaper and more rapid gains in the feed lot, and that its succulent nature causes cattle to shed the hair early and to look more attractive than those fed exclusively on dry feeds. A further advantage in Pennsylvania is that an excellent quality of corn silage can be produced in localities where the season is too short for corn to mature."

The value of corn silage as a part of the ration in fattening cattle is also shown from the results of a feeding test conducted at the Indiana Experiment Station. The results of this test are shown by Dean J. H. Skinner and Prof. F. G. King, in their Bulletin No. 163. These gentlemen state that:

The addition of corn silage to a ration for fattening cattle decreased the consumption of shelled corn in amounts closely approximating the grain content of the silage consumed by the cattle.

The addition of corn silage once daily to a ration of shelled corn, cottonseed meal and clover hay, reduced the cost of gains $1.83 per hundred pounds and increased the total profits $11.19 per steer.

The substitution of corn silage for clover hay in a ration of shelled corn, cottonseed meal and clover hay reduced the cost of gain $4.35 per hundred pounds and increased the profits $17.97 per steer.

The more nearly corn silage replaced the clover hay in the ration the cheaper was the gain and the greater the profit.

Corn silage produced a very rapid finish on the cattle.

The Missouri Experiment Station has secured from a large number of farmers in that state their experience in the feeding of silage.

In reply to the following question: "By feeding silage do you find your feed bill for the year is any less than when silage is not fed?" 196 correspondents out of 200 answered, "Yes;" two answered, "I don't know," and two said, "I can't tell yet." One hundred and fourteen of these men feed cattle.

Out of 114 replies to the following question: "Do you find that it requires less grain to fatten a steer when silage forms a part of the ration?" 112 answered, "Yes;" one replied, "I do not know," and one said, "I have not had enough experience to enable me to answer this question."

In answer to the question: "Do you find that it costs less to fatten a steer when silage forms a part of the ration?" 112 answered, "Yes," two answered, "I don't know."

The correspondent cattle feeders were also asked the question: "What per cent has the feeding of silage lessened the cost of production of beef on your farm?" Out of 79 replies, there was but one who was willing to say that there was no decrease in cost; 17 answered 25 per cent; 10 answered 33 1-3 per cent; 12 answered 50 per cent; while other replies were scattered over a wide range of gain.

A stock raiser writing to *The Independent Farmer* has this to say of the feeding of silage:

We consider the silo as necessary as our barns. In fact, we could not afford to do business on high-priced land without such economical feed as silage. It enables us to keep up a heavy milk flow from our cows at a very low cost. During the past year, in our cow testing association, one of our Holsteins returned us a profit of $131 over and above her feed, and we sold our silage to her at $3 per ton. Our entire herd returned us an average profit of $101.05, over and above their feed. This does not include the calf, manure, nor skim milk. These very gratifying results to us would have been impossible if we had not had a silo. We use silage a great deal to supplement our pasture. In fact, this coming summer we are going to feed silage and alfalfa the year around. We feed silage to everything on our farm. Brood sows especially relish a light feed each day, and during the suckling period it greatly stimulates the milk flow. Our hens are considerably better because of their receiving a liberal ration of silage. Our brood mares and colts have for their noonday meal during the winter about fifteen pounds of this excellent feed. In fact, we never had our colts grow better than since we started feeding silage and alfalfa. For all classes of live stock these two great feeds go hand in hand.

CHAPTER II

What a Good Silo Should Be

Before determining whether any particular type of silo is good or bad, it is necessary first to decide what are the requirements which make for efficiency in silo construction. It is only by applying certain standards to any article that we can decide on its fitness or unfitness for the purpose for which it was intended. It is therefore essential that everyone who has to do with silos, including the farmer, the builder, the agricultural engineer and economist, and the promoter of silo construction, should know how to value a silo to determine whether it will do the work expected of it and justify the expenditure of money which it requires.

Let us then set down the principal requirements for an efficient silo. It should be:

1. Airtight,
2. Moisture proof,
3. Fire proof,
4. Vermin proof,
5. Frost proof,
6. Strong,
7. Durable,
8. Cheap as to maintenance cost,
9. Round in shape,
10. Smooth as to interior walls.

Having thus arbitrarily stated our standards, at least most of which will be recognized as correct by anyone who understands the purpose of the silo, it will nevertheless be worth while to take up each one of these separately and determine the grounds of its importance.

(1) **Airtightness.** It is quite customary, as we have already done in the first chapter of this volume, to liken a silo to a giant fruit jar. And whether canning is being done in the home or on an extensive commercial scale in a canning factory, it is recognized as of prime importance that the contents of the can shall be sealed positively from the air. For this purpose a material which is absolutely airtight is used—glass in one instance, and tin in the other—and the seal is made in one case with a rubber gasket and in the other with a solder joint. The demand for the exclusion of air has a perfectly well recognized scientific basis. The spoiling of fruit or vegetables in a can, or the spoiling of silage in a silo by rotting, is simply a bacteriological action and will not take place unless oxygen be present to support the organisms which destroy the contents of the receptacle.

(2) **Imperviousness to Moisture.** It is necessary that the walls of a silo be impervious, not only to exclude moisture from the outside, which at times might enter in such quantities as to do considerable damage to the contents, but also to preclude the possibility of the natural juices in the silage from being lost. As previously pointed out, one of the advantages of silage is the fact that these juices are retained rather than being allowed to evaporate, as in the case of ordinary hay. So the silo which approaches closest to the ideal will be the one which retains the contents in as nearly its original condition as possible.

(3) **Fireproofness.** In addition to the value of the silo itself, the contents of the silo can perhaps be taken at a value of about $5.00 per ton as an average

figure. Assuming that one has a silo 16 feet in diameter and 40 feet high, the contents of this silo when full will weigh about 180 tons and will thus be worth about $900. The situation is easily imaginable, however, where the value of the contents of the silo could scarcely be estimated in dollars and cents—a situation where, if it were to be destroyed, the feeding value of its contents could be replaced only through much trouble and financial distress. Add to this fact that other consideration which is too lightly recognized, namely, that a fire on a farm is one of the most hopeless things in the world, placing everything in its wake practically at its mercy until its ravages are exhausted, and it is easy to understand why fireproofness is placed as one of the essentials of the ideal silo. A report of the fire marshal of Iowa shows that 480 barns were destroyed by fire in that state in a single year.

(4) **Exclusion of Vermin.** Not taking into consideration the destruction of the silage which may be accomplished by rats and other pests, it is necessary, in order to maintain the qualities enumerated under headings 1 and 2 above, that the construction of a silo be such as to exclude these animals. The silo cannot exclude air and moisture if it is of such a construction that rats or other animals can make holes through which they can run in and out freely.

(5) **Exclusion of Frost.** This is a consideration which will be a vital one in some latitudes, while in other parts of the country, where the winters are less severe, it is not of such important consideration. It is well recognized, of course, that frozen silage should not be fed to animals. The type of construction, therefore, which can completely exclude the frost, or at least re-

duce the amount of frozen silage to the minimum, is the efficient type to build.

(6) **Strength.** Experiments have shown, as noted in another chapter of this book, that the bursting pressure on a silo wall is 11 pounds per square foot for each foot of depth of silage; that is, in a silo built to a height of 20 feet, the bursting pressure at the bottom of the silo is 220 pounds per square foot. In addition to taking care of this inside pressure, the silo must also be sufficiently strong to withstand storms of various kinds. Winds of high velocity and much force are not uncommon and are especially prevalent in those parts of the country where the largest number of silos is likely to be built; and as climatic disturbances of this kind are more frequent in the spring and early summer, when the silo is likely to be empty, it is quite necessary that the silo itself have sufficient stability to meet these storms without any dependence upon the contents to weight it down.

(7) **Durability.** By this term is meant the ability of the silo to continue in service without appreciable impairment during a long term of years. The absolute cost of any structure is not the initial expenditure, but the cost per year through its period of usefulness. If for instance, a silo costing $240 has a life of 40 years, the capital investment is $6.00 per year. On the other hand, if a silo costing $60.00 has a life of but 4 years, the capital investment is $15 per year.

(8) **Maintenance.** This is a question which must be considered in close connection with that of durability. The structure in order to be efficient must not only entail a reasonable capital investment per year of life, but must also be as free as possible from maintenance cost. A silo which requires considerable time

spent upon it each year to maintain it in reasonably good condition is not as close to the ideal as we should be able to get. For one thing this maintenance is an annoyance and an expense, and for another thing it is likely to be frequently neglected, thus reducing the preserving power of the silo.

(9) **Shape.** The cylindrical silo is most economical of material, easiest to provide with resistance to working strains, easiest to fill. The absence of corners makes it practically impossible for air pockets to form if reasonable care is exercised in filling.

(10) **Smoothness of Interior Walls.** By having the interior walls smooth and free from ledges or offsets, the silage will settle down perfectly, thus effectually excluding the air and also allowing the largest possible amount of silage to be placed.

CHAPTER III

How Concrete Meets the Requirements

Having pointed out in Chapter II the standards of efficiency by which any silo must be judged, it is of interest to note how completely concrete as a building material fulfills all these requirements.

Concrete can, in the first place, be made both airtight and moisture proof. It is well known that the composition of concrete can be governed to suit the particular requirements in any case. If it is desired to make it impervious to both air and moisture, it is only necessary to so proportion the various sizes of aggregates and so regulate the amount of cement that dense and impervious concrete will result.

If it is desirable to further insure the non-porous nature of the concrete, it may have added to it some other ingredient for making it still more dense. There are a large number of such products on the market, perhaps most of which will answer very well the purpose for which they are intended.

The same result can also be attained by giving the concrete a surface treatment, either of a cement wash or of some proprietary pore-filling compound. There are also a number of these on the market, some of which have a bituminous or asphaltic base and could be used only on the interior walls, while others have a pleasing appearance, or are absolutely colorless, and could be used exteriorly.

It is generally conceded that concrete itself can, if given proper attention, be made sufficiently dense for all practical purposes; but with the addition of one or the other of these methods of excluding air and moisture, there can be no doubt whatever of the efficiency of concrete for silo construction so far as these qualities are concerned.

Concrete has proved its fireproof qualities on so many different occasions, and in so many different situations, that it is scarcely necessary to go farther than a mere statement of the case. There are on record

A Silo Which Withstood Fire on Farm of John H. McCoy, Harrisville, Pa.

instances of a large number of silos which have successfully withstood the ravages of fire where all other surrounding buildings have been destroyed. In addition to saving the silo itself, concrete is such a poor conductor of heat that if silo openings are properly protected, the contents of the silo will also be saved in good condition.

Concrete is proof against the attacks of vermin. There is no material which offers stronger resistance to the attacks of rats and other pests than concrete.

Concrete will give as good a protection against frosts as any other material. Of course this is a matter which varies greatly with the latitude, so that while in some localities frost does not have to be considered, there are other places where it is almost impossible to exclude frost entirely. In these latter localities it has been found that a double concrete wall with an air space intervening will reduce the destruction of silage by frost to a minimum. In fact, it is safe to say that there is no latitude where corn can be raised where a silo of this kind, if properly constructed, and with openings protected, will not keep the silage in practically perfect condition.

After a Cyclone Near Georgetown, Kentucky, in Which 81 Barns Were Destroyed in a Single County

In this connection, it might be well to suggest that frozen silage, which is often attributed to frost getting through the walls, is frequently caused by insufficient protection at the top. The fact that this freezing is only around the wall does not disprove this statement. The silage is of course colder next to the wall than it is in the middle of a silo, and with the loss of heat from above, the outside ring will naturally freeze first. As each day's silage is removed, the freezing continues on down, and the farmer believes that the silage is frozen for its entire depth. Investigation, however, would in many cases show that this is not so, but that it is frozen only a few inches below the surface.

As to strength, concrete is also subject to the will of the builder. By the addition of a sufficient amount of steel, he can build it to withstand any desired strain.

One of the pre-eminent qualities of concrete is durability. When once built, and built right, it is practically indestructible. It is sufficiently heavy to maintain its position against winds or other elemental forces, and it is not affected by age, except that as it grows older, it grows stronger.

The objection has often been raised against cement that it is affected deleteriously by the acids in the silage. This contention has never been proven and there are numberless authoritative statements to the contrary. It might be pointed out, however, that even if there should be a slight eating away of the concrete by these acids, such action can effectually be counteracted by some asphaltic or bituminous preparation once every three or four years. If such a coating as this is considered necessary, this is practically the only item of maintenance cost which it will be found necessary to expend upon the silo other than perhaps occasional renewing of the roof, unless a concrete roof should be put on in the first place. Concrete, therefore, admirably fulfills the requirements of low maintenance cost.

One of the manufacturers of concrete silos has gone to considerable trouble to gather expressions of opinion from the various agricultural colleges regarding the concrete silo. An expression was especially asked on the question of the effect of the acid in silage on concrete, since this is one of the main arguments used

Three Concrete Silos in Perfect Condition After a Wind Storm
—Photo by Courtesy of Sanders Pub. Co., Chicago

by the opponents of concrete silos. Some of these statements are as follows:

It has been our experience on the college farm, and the experience of the men for whom we have supervised the construction of the cement silos, that when properly built they preserve silage in first-class shape. We have never noticed the effect of the acid of silage on the walls of a concrete silo.—O. E. Reed, Professor of Dairy Husbandry, Kansas State Agricultural College, Manhattan, Kansas.

I think it has been definitely established that among all types of silos, the concrete silo is one of the most durable. The action of the acid in the silage on the durability of the concrete is not a large factor in any event, and when the silo lining is covered with a proper glazed coating, this action is practically negligible. —F. B. Mumford, University of Missouri, Columbia.

A silo, if made with impervious walls so as to exclude the air and retain the moisture, if made so as to be sufficiently rigid and of sufficient strength to resist the bursting pressure of the silage, and lastly if smooth on the inside to permit the silage to settle properly, will keep the silage regardless of the kind of material used in the construction. Concrete silos can be made to meet all these requirements. There is abundant evidence of this and in no case have we found spoiled silage in any silo where these essentials were incorporated.—J. B. DAVIDSON, Professor of Agricultural Engineering, Iowa State College, Ames.

I have constructed quite a number of concrete silos and have found that when the concrete silo is constructed properly, it will preserve the silage in good condition. I have also found that the acid of silage has very little effect on the concrete.—J. W. RIDGWAY, Professor of Dairy Husbandry, Agricultural and Mechanical College of Texas, College Station.

Concrete silos on the whole will keep silage as well as any other silo. With concrete walls made of properly proportioned and well mixed cement, sand, gravel, and the inside washed with grout, one need not fear injury to the walls due to the acids in the silage. I have examined quite a number of concrete silos and have not seen a single one where the acids have made any permanent injury to the walls. It is my opinion that the effect of the acids in silage on a concrete wall is a minor matter.—C. F. CHASE, Assistant Professor Agricultural Engineering, North Dakota Agricultural College.

It is my opinion that concrete silos keep silage as well as other makes, and that when the concrete of the silo is properly glazed the acid in the ensilage does not have any injurious effect upon the concrete.—W. L. FOWLER, Head Department of Animal Husbandry and Dairying, University of Arkansas, Fayetteville.

There is positively no truth in the statement that cement silos are destroyed by the acids in the silage. These silos have been in use for about twenty years. A few days ago I was talking to a gentleman who had just examined a stone silo that was plastered with cement plaster twenty-five years ago and had not been repaired since, and it is now in perfect condition. We have seven of these concrete silos on the college farms that are keeping silage fully as well, if not better, than our two wooden silos.—A. S. NEALE, Dairy Husbandry, Kansas State Agricultural College, Manhattan, Kansas.

A great many objections are made to concrete as a suitable material for silo construction. These statements, of course, come from competing builders, mostly wood stave silo people. Observations of concrete and wood stave silos standing side by side show that the freezing is not greater in one than the other. By coating the concrete walls with a wash of neat cement or tar pitch they can be made perfectly air, water and acid proof. That concrete stave silos are a success has been demonstrated beyond a doubt by those built, not only in this state, but other states as well. Silos of this type are known to have been used successfully for eleven years without the least sign of deterioration or loss of silage through spoilage.—AGRICULTURAL EXPERIMENTAL STATION, Ft. Collins, Colorado.

Concrete silos have been in use for at least fifteen years in this state, and are giving excellent satisfaction. There is no serious effect of the silage acid on the concrete.—F. M. WHITE, Department of Agricultural Engineering, University of Wisconsin.

Concrete can very readily be made round in shape. It is the most plastic material of any with which the silo builder will have to deal, and can be fitted perfectly to his requirements in every way.

Concrete can be given absolutely smooth interior walls. In monolithic silos, the walls will automatically assume a smooth surface if proper care is used, even without any surface treatment, while where concrete units are used, these form an admirable surface on which to plaster or to apply any smooth surface coating.

CHAPTER IV

Advantage Over Other Kinds of Silos

In addition to concrete there are five materials which are sometimes used for the construction of silos —stone, brick, structural tile, wood and iron.

In every one of these concrete is almost invariably used at some point: for the foundation wall, the floor, the mortar with which the units are held together, the surface finish, or the roof. This being the case, it is coming to be more and more asked, Why, if concrete is a good material for these parts of a silo, should it not be used for the entire structure. It would be worth while thus to do away with the complications arising from the use of two or more different materials, if for no other reason.

None of the materials enumerated has any advantages over concrete as a material for silo construction. Some of them have decided disadvantages, as a careful study of them will show.

Of all the above materials, stone comes perhaps nearest to having the high percentage of efficiency of concrete, so far as most of the requirements are concerned; and yet, in the face of this, it is the one material which has been almost abandoned for silo construction. This is not to be wondered at when one comes to consider the matter; for it is a slow and expensive construction, giving no increased benefit for its increased cost. There are comparatively few farms which are situated advantageously with respect to a supply of stone suitable for building purposes; while if such a supply is available, it is a slow process, and one requiring the employment of expensive skilled labor, to work this stone into shape and lay it up in the wall.

Then, too, ordinary building stone at the best will usually show a greater degree of porosity than good concrete. It is easy to see why this is so. Concrete is, to be sure, composed of stone—possibly even a poorer grade of stone than would be considered fit for masonry work; but in concrete each particle of stone is covered with a film of cement, while in stone masonry there is no such protective coating. But with a scarcity of stone, there is always a probability that one who wants to build with this material will be satisfied with less than the best, thus working into the structure a material of even greater porosity, and possibly one also which will disintegrate rapidly under the action of the elements. Neither will stone give a sufficiently smooth interior surface, making it necessary to give it a plaster coat if the best results are to be secured.

Brick is open to the same objection as stone, so far as porosity is concerned. Tests made at various times and places have established beyond question the fact that a well made concrete has a greater density, and will consequently exclude air and moisture more perfectly, than any grade of brick which would be likely to be used in silo building. Brick is also inexpedient for this purpose because of the fact that it usually has to be hauled a considerable distance, and on top of this haulage cost is often a freight bill for shipment by rail from a distant brick yard. In the case of brick, too, practically all the material has to be hauled in, the only local material used being a small supply of sand for mortar, if such is obtainable, though the local supply might be of such a quality that, while very good for concrete work, the bricklayer would not consider it of the right quality for mortar.

One of the great advantages of concrete for any work on the farm has always been that local materials could be utilized to a large extent, not only cutting down the hauling, but, where a good grade of sand and gravel is found on the owner's own farm, making the cost of it practically nothing. In this day of the study of economics and the demand for efficiency along all lines, it would indeed be a sad reversion to inefficient methods for a man to bring in outside materials at a loss not only of hauling time, but of actual cash, when he has suitable materials right at hand.

Forty-Two Acres of Corn Spoiled by the Collapse of This Clay Tile Silo

It is a difficult matter to properly reinforce a brick silo. The reinforcing can be placed only in the mortar joints between the courses. a more difficult operation, and giving less strength than where the rods are embedded in the concrete, as in the case of monolithic concrete work, or where they have special grooves made to receive them, as in the case of concrete blocks, or, again, where they completely encircle the silo, as in concrete stave construction. Bricks, too, present flat surfaces to each other, having no bond except the mortar joint which connects them, while concrete blocks made especially for silo work usually have some device for interlocking them in both directions, thus making them stronger to withstand strains either from within or without. And brick are open to the same objection as stone in that they do not present a smooth interior surface.

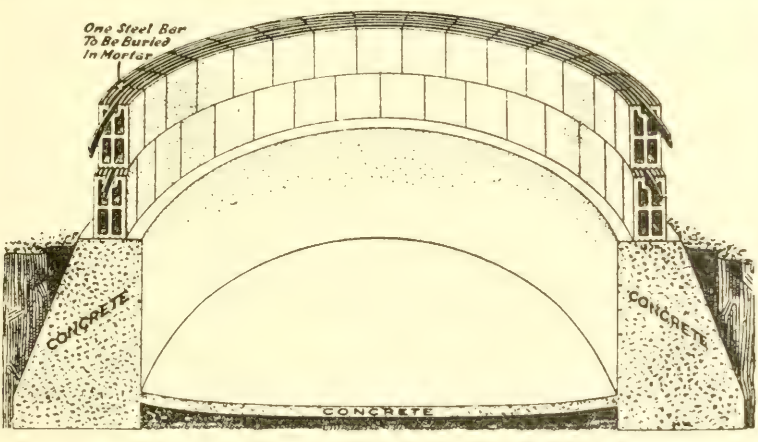
This Vitrified Tile Silo Collapsed First Night After Filling. On Farm of Neff Wildrick, Colusa, Ill.

With slight modifications, the same objections that have been stated against brick will hold good as against structural tile. The air space of the structural tile will to a certain extent atone for its porosity; but on the other hand it is more expensive than brick and is even more difficult to secure, as it is made only in widely separated plants.

In view of the claim of the opponents of concrete that it will be destroyed by the action of the acids in silage, it is interesting to note the illustration here reproduced from an extensive article by one of the exponents of clay products. He calls concrete a "good form of foundation for a hollow block silo"; but if it is good enough for the foundation, where the juices gather and the acids are the strongest, why should he consider it such a dangerous material for the body of the structure?

There are perhaps more wood silos sold than any other kind. One reason for this is that they are cheap, and another is that they are short lived and have to be replaced frequently.

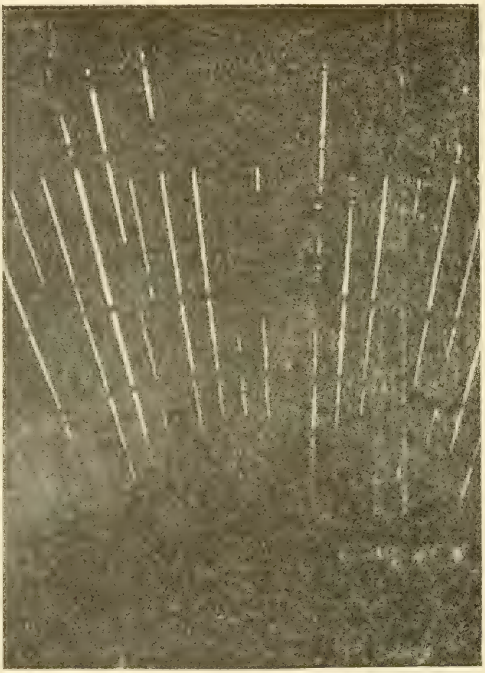
Certain qualities that are inherent in the very nature of the material of which wood stave silos are



A Good Form of Foundation for a Hollow Block Silo.

Illustration Reproduced from "Brick and Clay Record," Showing Concrete Recommended as Foundation and Floor For a Silo

made of necessity take them out of the class of permanent structures and put them in the class of temporary expedients. Wood is not an enduring material, especially when exposed to the weather. The very nature of wood is such that it shrinks when dry and swells when wet. The permanency of a wood stave silo depends entirely upon its maintaining a constant rigidity of structure. It consists of staves set on end, held firmly in place by hoops. As long as the hoops remain tight the structure will be comparatively rigid and stable. As soon as the hoops become loose, it becomes in the highest degree unstable. In the modern wood stave silo the staves are matched and fitted together by tongue and groove. The tongue and groove are from ½ to ⅝ inch in depth. The extreme circumference of a silo 16 feet in diameter is about 50 feet. It would take very little shrinking to reduce this 50 feet sufficiently to separate a tongue from a groove. Then, unless some method is adopted for holding the stave in place, the stave will fall out and the silo be in imminent danger of collapse. If the hoops become loose so as to destroy the rigidity of the structure, it may be worked in any direction by every light wind.



Effect of Shrinkage of Wood Staves

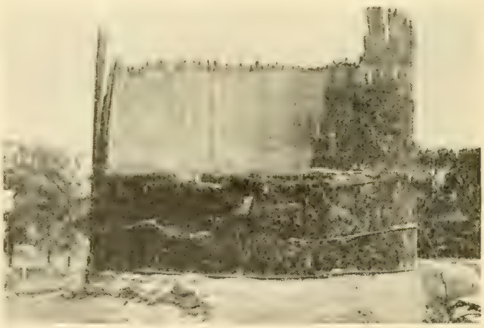
A single half day of hot weather is sometimes sufficient to shrink the staves on such a silo to such an extent that every hoop will need to be tightened in order to make the structure safe. When the hoops are so tightened, a single shower of rain will swell them to such an extent that either the staves will buckle or the hoops will break. Of course, there can be nothing permanent about a structure made of material in which such qualities are inherent. An illustration printed herewith is made from a photograph taken on the inside of a silo and shows the effect produced by shrinking. No one will imagine for a moment that such a silo would stand erect under a mild wind. When a silo collapses it is a matter of considerable expense to erect it again. No farmer will be satisfied with a silo that requires such constant attention and is in such constant danger.


Wood Stave Silo Displaced by Wind —*Photo by Courtesy of Virginia Agr. Exp. Station*

It is reported by *The Twentieth Century Farmer* that a wood stave silo was erected on the state fair grounds at Lincoln, Neb., solely for exhibition purposes by a company engaged in promoting the sale of just such silos. It may be taken for granted that it was erected in the best way possible, in strict accordance with the mechanical principles involved in proper erection. But one side of the silo was blown in, thus rendering it practically worthless until it had been repaired.

During the summer of 1911 thirty-one stave silos erected in the vicinity of Lincoln, Neb., were inspected. In the inspection no silo was passed by. They were taken singly one by one as they were found. Here is the result of the inspection:

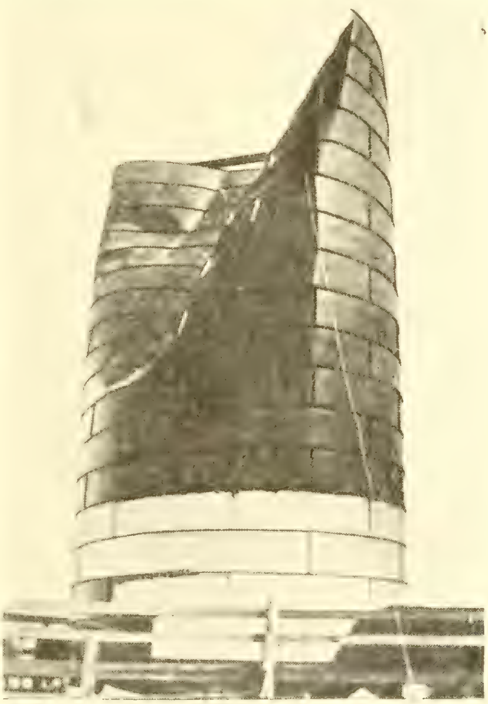
Five had blown clear down once before they had been built twelve months; one blew clear down twice before it had been built twelve months; one blew clear down three times before it had been built twelve months; one blew clear down once before it had been built five years; one blew clear down once before it had been built nine years; two blew clear down, but the date of their erection was not ascertained; eight had been re-erected once before they were up twelve months; one had been re-erected twice before it was up twelve months; four were leaning badly; one had been straightened twice; two had very loose hoops; one had broken nearly every hoop more than once; only six were in good condition.



Wood Stave Silo After a Fire

With such a record as this, it is impossible to classify wood stave silos as permanent structures, and this impossibility rests not, as the wood stave silo men claim, upon failure to observe mechanical principles in the erection of them, but upon qualities inherent in the very nature of the material itself. Nor can such a state of affairs be charged to the fact that these silos were not properly guyed, because no guying is sufficient to hold such material in place with a proper degree of rigidity to insure stability.

No wood exposed to the action of the elements is safe from decay. The rains that beat upon the outside of a silo, the change in moisture conditions and in temperature, the absorption of moisture from the enclosed silage, all help to hasten the process of decay.


Failure of Metal Silo on Farm of E. W. Page, Goltry, Okla.

The Twentieth Century Farmer also states that it has on file a statement from a representative of a wood silo company to the effect that 25 per cent of the ensilage in concrete silos rots beyond use. The editor brands this unhesitatingly as a false statement. This paper has made an extensive investigation of silos, and in the course of this investigation, concrete silo after concrete silo has been visited. In no case has dissatisfaction with such a silo been found by the user. Such silos have been in use for a number of years. The investigators have not been able to find an owner of a concrete silo who would build a silo from any other material.

Relative to the action of acids on silos the publication above quoted says: "It is very glibly stated by the salesmen of wood stave silos that the acetic acid developed by the process of fermentation in ensilage corrodes and eats away the concrete wall so as ultimately to destroy it. This statement at first glance would seem to have some basis of truth, for the reason that it is a well-known fact in chemistry that acetic acid will attack some of the materials of concrete wherever found, and thereby produce acetates. This fact has been magnified and has been used by wood silo men to damage the reputation of concrete silos. But here is another fact: The amount of acetic acid developed in fermenting ensilage is so small and is so much diluted that it has practically no effect whatever upon the concrete. Concrete silo after silo has been visited, some of them having been in use for more than 25 years, and in no case has the least evidence of the action of acetic acid upon the silo wall been discovered. The walls are as smooth and clear and clean after 25 years of service as they were in the first place.

"The greater initial cost of masonry silos is another argument used against them by the wood silo men. This argument might be made valid if the wood silo men would put their price where it might be regarded as reasonable. This fact, however, must be remembered—that the first year's loss on a wood silo that blows down during the first year and has to be reerected amounts to more than the initial cost of any masonry silo. The masonry silo, when properly reinforced, is a permanent structure. There are no hoops to tighten, no danger from blowing down or from fire. It grows stronger and more stable with each succeeding season. It is good for generation after generation. In some places, owing to cost of material, the initial cost may be a little more than the cost of a wood stave silo, but in the end it is a more economic structure.''

With reference to the metal silo, it will scarcely be necessary to do more than quote a paragraph from the catalogue of one of the companies selling these silos. It states:

''In the production of silage, certain mild acids are formed by fermentation, which, if no protection were afforded, would have a tendency to cause the galvanizing to corrode. To provide against this it is advisable to keep the inside of the silo painted with some elastic, acid-resisting paint.''

In another paragraph the company advises its customers to paint the inside of the silo once a year; and this, too, is a company which is selling silos of ''pure iron''—the kind which is supposed to be proof against attacks of any kind.

Granting that the acid in silage does have a slight effect upon concrete, such a wall, with a thickness of several inches, will certainly be more durable than a metal wall having a thickness of a small fraction of an inch.

The table on the following page, which is a compilation of 296 replies to inquiries sent out to Missouri farmers, will serve to show the difficulties experienced with silos of various kinds and the kind of silo preferred, if another should be built.

TABLE I—RESULT OF INQUIRIES MADE AMONG 296 MISSOURI FARMERS

Kind of silo in use	No. in use	Number giving trouble	Per cent giving trouble	Kind preferred if another should be built: Concrete	Stave	Gurler	Home-made
Stave	234	Loose hoop & staves, 77	33	38	196		
		Blowing down, 15	6.5				
		Frozen silage, 8	3.5				
Solid concrete	33	Cracked, 1	3.	33			
		Frozen silage, 1	3				
Concrete block	12	Cracked, 2	16.66	11			
		Frozen silage, 1	8.33				
Gurler	9	Frozen silage, 3	33.33	3		6	
Home-made sheeting & tar paper (Gurler type)	4	Frozen silage, 1	25	1			3
Buff Jersey	4	Frozen silage, 1		1			
		Spoiled silage, 1					

From this table it will be seen that the preference is for the concrete silo if another kind is discarded. Out of one hundred men having some difficulty with the stave silo, 38 prefer the concrete if they should build another silo. Not a man having a concrete silo expressed a desire for another kind in the event that he should build another.

CHAPTER V

Size and Shape of a Silo

As has previously been stated, economy and good construction will dictate that the general shape of the silo be cylindrical, and there are at the present time practically no other shapes used.

It is generally understood, too, that in an economic and well constructed silo certain relations must be maintained between the diameter and the height. It is sometimes stated that the depth of the silo should not be less than twice nor more than three times the diameter. This rule has, of course, been violated in both directions, but it is probably a less serious error to go above this rather than below. In fact, higher silos are now advocated by some of the best builders, and there is a tendency in some sections to build silos higher than formerly.

It is of course recognized that the greater the depth of silage, the better will it be on account of the pressure from above forcing out the air and helping to preserve it. If the height is less than 24 feet, the quality of the silage will not be of the best. On the other hand, an excessive height will increase the cost of filling the silo by making necessary a larger amount of power to elevate the material into it. It will also necessitate a long climb for the person whose duty it is to get the silage out.

Within the limits defined, it is an easy matter to figure out the size of silo required in any given location. The two dimensions will in general be fixed by two different considerations. The diameter of the silo will be determined by the size and nature of the herd to be fed, and the height by the number of feeding days per year for which it is desired to provide. A common error in building a silo is to make the diameter too great for the size of the herd. When once a farmer has removed the top layer from his silage and has commenced to feed from it, the silage should be removed at the rate of not less than 2 inches in depth per day in the winter time and 3 inches in the summer time. It is necessary to establish a limit of this kind in order to insure that none of the silage shall spoil.

The weight of a cubic foot of silage varies according to the pressure to which it is subjected, but there are certain average figures which can be taken as sufficiently accurate. For instance, in a silo 30 feet deep, a cubic foot of silage will average about 40 pounds in weight; so by knowing the amount of silage to be fed daily, it is possible to estimate what the diameter of the silo should be to permit the removal of a certain number of inches in depth each day.

Table II, which is taken from Bulletin No. 21 of the Association of American Portland Cement Manufacturers, shows the approximate minimum pounds to be fed daily from the various diameters of silos. This is based on winter feeding, and for summer feeding would, of course, be about 50 per cent more, in order to keep the silage in good condition. This table also shows the number of animals which can be fed from each silo on the amount taken away daily at a stated ration for each kind of animal. Of course, many feeders will not make out their rations according to this table; but with the help of the table, and substituting their own weight of rations for the ones used in the table, they can determine very accurately what size herd they can raise on any diameter of silo, or conversely, they can determine the size of silo necessary for any given herd. Multiplying the depth taken away each day by the number of days which they desire to feed, they will be able to get the height of silo necessary. The usual figure taken is 180 days, although the increasing preva-

TABLE II—SHOWING MINIMUM NUMBER OF ANIMALS TO BE FED DAILY FROM EACH DIAMETER OF SILO

Diameter in Feet	Approximate Minimum Pounds to be Fed Daily	Number of Animals to be Fed from each Size of Silo					
		Horses 11 lbs per day	500-lb Calves 12 lbs per day	Stock Cattle 20 lbs. per day	Beef Cattle 25 lbs per day	Dairy Cows 40 lbs per day	Sheep 3 lbs per day
10	525	48	44	26	21	13	175
12	755	69	63	38	30	19	252
14	1030	94	86	52	41	26	344
16	1340	122	112	67	54	34	446
18	1700	155	142	85	68	42	567
20	2100	191	175	105	84	53	700

lence of summer feeding is another factor which is helping to increase the height of silos.

Table III, taken from Bulletin 141 of the Iowa Agricultural Experiment Station, gives the capacity in tons of various diameters and heights of silos; also the number of acres necessary to fill the silo at 15 tons per acre, and the amount which should be fed daily, this amount corresponding to that given in the second column of Table II.

The Wyoming Farm Bulletin suggests that the following formula may prove serviceable in estimating the actual amount of silage in the silo, assuming that 1 cubic foot of ensilage weighs 30 pounds:

TABLE III—CAPACITY OF SILOS AND ACREAGE NECESSARY TO FILL

Inside Diameter	Height	Capacity Tons	Acreage to fill. 15 tons to the acre	Amount that should be fed daily Pounds
10	28	42	2.8	525
10	30	47	3.0	525
10	32	51	3.4	525
10	34	56	3.7	525
10	38	65	4.3	525
10	40	70	4.6	525
12	28	61	4.1	755
12	30	67	4.5	755
12	32	74	5.0	755
12	34	80	5.3	755
12	36	87	5.8	755
12	38	94	6.4	755
12	40	101	7.3	755
14	28	83	5.5	1030
14	30	91	6.1	1030
14	32	100	6.7	1030
14	34	109	7.2	1030
14	36	118	7.9	1030
14	38	128	8.5	1030
14	40	138	9.2	1030
16	28	108	7.2	1340
16	30	119	8.0	1340
16	32	131	8.7	1340
16	34	143	9.5	1340
16	36	155	10.3	1340
16	38	167	11.1	1340
16	40	180	12.0	1340
18	30	151	10.0	1700
18	32	166	11.0	1700
18	34	181	12.0	1700
18	36	196	13.2	1700
18	38	212	14.1	1700
18	40	229	15.26	1700
18	42	246	16.4	1700
18	44	264	17.6	1700
18	46	282	18.8	1700
20	30	187	12.5	2100
20	32	205	13.6	2100
20	34	224	15.0	2100
20	36	243	16.2	2100
20	40	281	18.8	2100
20	42	300	20.0	2100
20	44	320	21.3	2100
20	46	340	22.6	2100
20	48	361	24.0	2100
20	50	382	25.5	2100

$$\left(\frac{D}{2}\right)^2 \times 3.14 \times H \times 30 = \text{pounds of silage.}$$

Where D equals diameter of silo in feet.
H equals depth of silage in feet.
30 equals weight of silage per cubic ft.

EXAMPLE: To get the capacity of a silo ten feet in diameter containing twenty feet of silage.

$$\left(\frac{10}{2}\right)^2 \times 3.14 \times 20 \times 30 =$$

$$5^2 \times 3.14 \times 20 \times 30 =$$

$$5 \times 5 \times 3.14 \times 20 \times 30 = 47{,}100 \text{ pounds silage.}$$

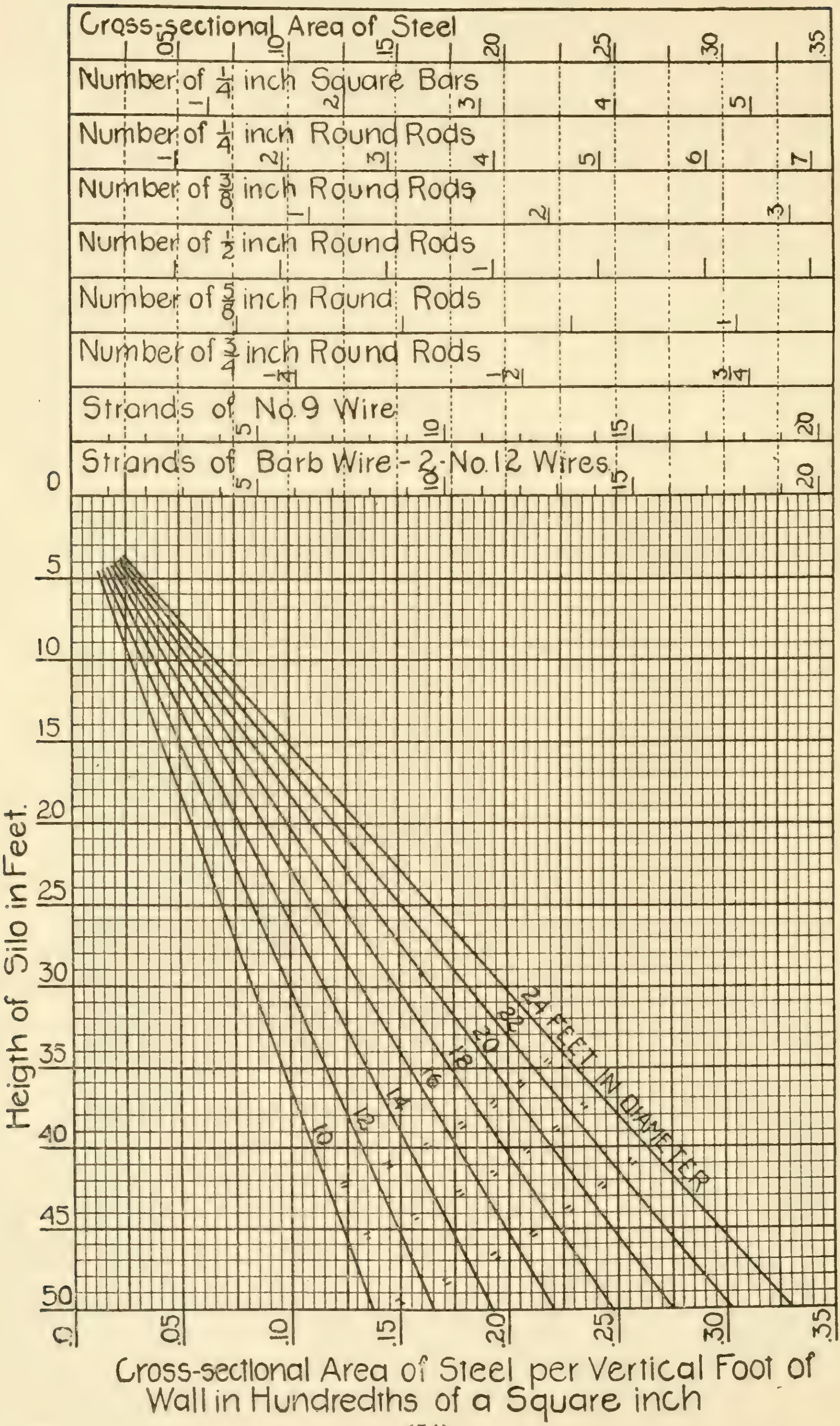
$$47{,}100 \div 2{,}000 = 23.5 \text{ tons of silage.}$$

In the eighth annual report of the Wisconsin Agricultural Experiment Station, Prof. F. H. King gives the results of investigations to determine the pressure of silage against the silo wall. It was found in these experiments that the pressure of silage upon the silo walls increases with the depth and is equal to 11 pounds per square foot of each foot of depth. Thus at a depth of 20 feet, the bursting pressure in a silo is 220 pounds per square foot, and at a depth of 35 feet the pressure amounts to 385 pounds.

Prof. J. B. Davidson, of the Iowa Experiment Station, Ames, Ia., says that a careful investigation of modern practice proves that an allowance for this pressure is sufficient, and that many concrete silos are now standing and in successful service with much less reinforcement than that required by an assumed pressure of 11 pounds per square foot per foot of depth. This is due to the fact that the wall independent of the steel is able to resist a part of the bursting pressure.

Table IV, prepared by Prof. Davidson, gives the steel required in cylindrical silos to carry a bursting pressure of 11 pounds per square foot per foot of depth and it is based on a safe tensile strength of 20,000

TABLE IV—TO DETERMINE STEEL REQUIRED IN REINFORCING SILOS



pounds per square inch for the steel. This shows in a concise form the cross-sectional area of steel required in silos from 10 to 25 feet in diameter for the top foot and each successive foot until a depth of 50 feet is reached. The chart should be held in a vertical position. Then, if the point is noted where one of the heavy diagonal lines representing a silo diameter intersects a horizontal line representing the depth of the silo, the area of the steel required to resist the bursting pressure on a section of the silo wall one foot wide will be found on the scale directly below. The corresponding area in common styles of reinforcement is found directly above on the upper scales.

CHAPTER VI

The Different Types of Concrete Silos

Concrete silos naturally divide themselves into two broadly general classes: Those which are built up in position and which form when completed one practically continuous monolithic mass; and secondly, those which are built up from structural units of concrete previously manufactured.

This is a classification somewhat different from that used by other writers on this subject, but it is believed that careful consideration will show it to be logically correct.

The metal lath silo, for instance, has usually been considered in a class by itself, and apart from the monolithic silo. In any broad general classification, however, it would seem to belong with the monolithic silo inasmuch as it is built up in place and forms practically one solid mass when completed, the main difference being that it is plastered in vertical layers instead of being poured in horizontal sections. The pit silo, if it is considered at all, will also come under this classification, it being a plastered silo underground instead of above ground.

This first classification will also include the hollow wall silo when poured in place.

The second classification will include the silo built of concrete blocks, concrete staves, or any other form of structural units which are made previous to the erection of the silo.

The determination of the particular type of silo to be erected in a given place will depend upon a number of considerations. While there may be several things which in any given locality will point to one type of silo as somewhat more suited to the conditions than another, the principal consideration governing the choice will in most cases be found to be the whim of the owner. It is unfortunate that this is so, but it is one of the conditions to be reckoned with. Aside from this, however, there are logical conditions which will influence, or should influence, the choice of type. Two extreme cases might be cited as illustrating this.

Suppose, for instance, that there is a good deposit of sand and gravel on a man's farm, and that there is a contractor in a nearby village who has a set of forms for building monolithic silos, and with a reputation for building them well; these conditions would naturally point toward the monolithic silo for this particular location. On the other hand, suppose another farmer, who has no available deposit of sand and gravel, but who is within convenient hauling distance over good roads from a plant where he can procure structural units of some kind for silo construction. These conditions will as certainly point to the use of such units.

There will, of course, be many modifications of these conditions, at some time some of them possibly pointing in one direction and some in the other. They will then have to be weighed against each other and the decision made in the direction of those which seem to be most favorable.

The labor situation may influence the selection somewhat. If stone masons are available and plasterers are not to be had, this would tend to make one favor the silo of structural units as opposed to the metal lath silo; while with reverse conditions, the opposite would be the case. A strike in one of these trades would, of course, throw that particular mode of construction out of consideration for the time being.

The fact that a neighbor has a silo of a certain type of construction will often influence a man to have the same type. This method of selection is logical only to the extent that it shows there is someone in the locality who can build successful silos of that type and gives the new builder greater confidence that his silo will be what it should be. His situation as to materials or labor, however, may be entirely different, so that this in itself is not sufficient basis for choice.

There may even be times when one will not be justified in going to greater expense than that involved in the construction of a pit silo. In doing this, however, he must be sure that his conditions are right for this type of silo, and outlined in another chapter of this book.

CHAPTER VII

The Foundation of the Silo

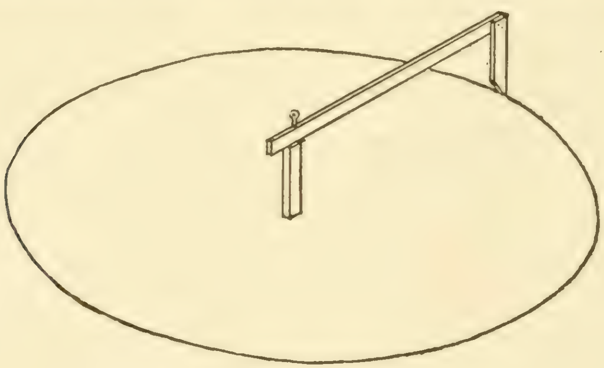
The silo is usually allowed to extend into the ground about 5 feet. In this way the height above ground is reduced, considerably decreasing the amount of scaffolding necessary, and the hoisting of materials, as well as having the further advantage of placing the foundation below the frost line.

It might at first seem that if a depth of 5 feet is an advantage, a greater depth would be a still further advantage; but this is not true, owing to the fact that when one goes below 5 feet, the difficulty of getting the silage out of the silo offsets any advantages of construction which might be secured.

When the site of the silo has been selected, a stake is driven in the center and a sweep is attached to this stake with a spike, by which the place for excavation can be marked out. This sweep may consist of a piece of 2x4, or any other convenient piece of lumber, to the outer end of which is attached a pointed piece of board, by which the marking can be done. The length of the sweep will of course be governed by the diameter of the proposed silo, as well as the nature of the ground in which the excavation is to be made. First measure off on the sweep from the spike in the center stake, one-half the inside diameter of the proposed silo. If the ground is firm, so that the walls will stand vertical, 1 foot can be added to this radius. If, however, the ground is soft and yielding, so that it will be necessary to slope it back, it will be necessary to add about 2½ feet.

If a floor is to be put in, the excavation should be carried down to 4 inches below the top level of the floor, making a 4-inch slab.

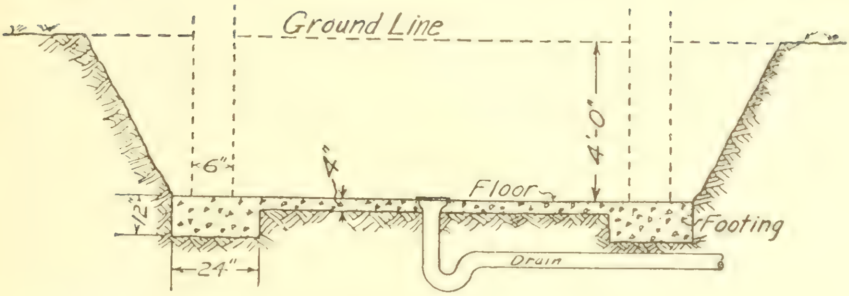
Under certain conditions, the silo floor may be dispensed with without interfering with the preservation of the silage. Where the silo rests upon dry clay or any non-porous soil, and where the foundation is deep enough to prevent undermining by rats, the floor may be omitted. In general, however, a floor is quite desirable. The portion of the silo below the ground may be made more nearly water tight, the floor may be thor-



Sweep for Laying Out Excavation.

oughly cleaned, and there is no mixing of earth with the silage. A silo floor need not be thick or expensive, as the weight of the silage, though very great, is distributed evenly over the surface and would be just as firmly supported if the floor was not used.

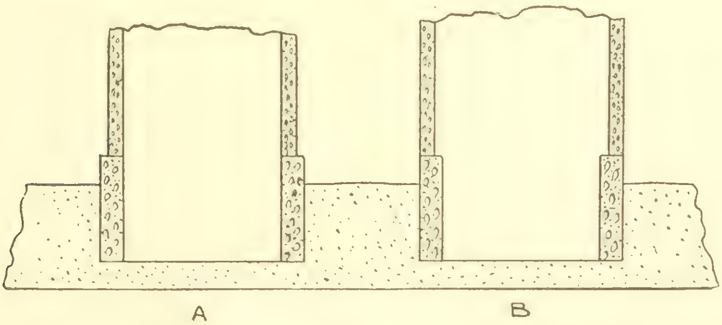
After the excavation is leveled off for the floor of the silo, the digging is then continued around the circumference of the pit for an additional depth of 8 inches, and 24 inches in width, to provide for the footings, as shown in the drawing. It is a good plan to provide in the center of the silo floor a connection with



Excavation, Floor and Footing. Earth Wall Can Be Made Vertical Where Ground Is Firm.

a line of drain tile. This drain will carry off any water which may accumulate in the silo, and which, in some cases, has been known to rise to such a height as to exert a pressure on the silo walls greater than they were designed to resist. If a drain is used, the floor of the silo should have a pitch toward the center of about ¼ inch to 1 foot. The drain should also be covered with wire netting to keep it open, and should be provided with some form of trap so that the air cannot enter from the outside.

If the foundation walls on the silo are made thicker than the walls of the superstructure, they should line up with each other on the inside rather than the outside. A few years ago it was thought proper to place



Correct Method of Alignment Between Wall and Foundation Shown at A. Incorrect Method at B.

the upper part of the silo at the outer edge of the foundation walls. The shoulder was thus left projecting into the silo. Owners of such silos report a large amount of rotten silage around the joints. This is owing to the fact that the silage does not settle properly where such joints occur, leaving pockets of air which cause rotting of the silage. In some cases the owners have felt it worth while to sacrifice a part of the capacity of their silos by filling them up to this shoulder.

If the ground is firm it can be used as an outside form for the foundation walls, using an inside form of wood or metal.

It may be said, however, that while it has been the custom in the past to build a foundation wall up to about a foot above ground, irrespective of the kind of construction to be followed above that point, the practice is coming into quite general use of starting the walls of the structure directly on the footing, making them uniform from that point to the top, whether they be of monolithic construction, blocks, staves, or plastered on metal lath. This is a more simple method of construction, except for the fact that in some instances this may require a little more excavation.

Where a silo is to be reinforced vertically, this reinforcement should be imbedded in the footings and allowed to project from them up into the walls.

CHAPTER VIII.

The Monolithic Silo.

The word "monolith" is derived from two Greek words and means, literally, a single stone. The term "monolithic" is therefore applied to concrete structures which are built up in one continuous process and form practically a single stone when they are completed.

As stated in a previous chapter, any broadly general classification of silos would include under this heading not only the silo which is built up of either solid or hollow walls poured in forms, but also the pit silo and the silo plastered on metal lath. These others are, however, dealt with in separate chapters further on in this volume; and as a number of different systems have been developed for constructing the silo of poured walls, these too have been dealt with in other chapters, so that this chapter need only concern itself with a few general observations on this type of silo.

It has been the custom in the compilation of bulletins by the U. S. Department of Agriculture, the experiment stations of the several states, and the bulletins of the cement companies, to give detailed directions for what are known as "home-made" silos; that is, silos built wholly or largely by the farmer himself, and in forms which are also of his own manufacture. The present writer, after having given the subject careful consideration, has not seen fit to include such matter in this volume. While undoubtedly a large number of very satisfactory silos have been built in this way, the practice is not to be recommended. The

TABLE V.—AMOUNT OF CONCRETE MATERIALS FOR COMPLETE SILOS OF VARIOUS DIAMETERS (INSIDE)

These figures include footings and floor, but no roof. Walls 6 inches thick. Continuous doors 2½ feet wide. Figures are for barrels of cement and cubic yards of sand and gravel.

Height of Silo in Feet	8 FT DIA			10 FT. DIA			12 FT DIA.			14 FT. DIA.			16 FT. DIA.			18 FT. DIA.			20 FT DIA.		
	Cement	Sand	Stone	Cement	Sand	Stone	Cement	Sand	Stone	Cement	Sand	Stone	Cement	Sand	Stone	Cement	Sand	Stone	Cement	Sand	Stone
20	16 5	5 1	10.2	21 0	6.5	13.0															
22	17 9	5.5	11.0	22 7	7 0	14.0															
24	19.2	6.0	12.0	24.5	7.5	15.0	29.6	9.1	18.2												
26	20.5	6.3	12.6	26.1	8.0	16.0	31.7	9.8	19.5												
28	21.9	6.7	13.4	27.1	8.5	17.0	33.8	10.4	20.8	39.8	12.2	24.4									
30	24.2	7 1	14.2	29.7	9.0	18.0	35.9	11.0	22.0	42.3	13.0	26.0									
32				31.2	9.6	19.2	37 9	11.6	23.2	44.7	13.7	27.4	51.3	15.9	31.8						
34				32.9	10 1	20.2	40.0	12.2	24.4	47.1	14.4	28.8	54.3	16.7	33.4						
36				34.6	10.5	21.0	42.1	12.8	25.6	49.4	15.1	30.2	57.1	17.5	35.0	64.8	19.9	39.8			
38				36.4	11 1	22.2	44.0	13.4	26.8	51.9	15.8	31.6	59.8	18.3	36.6	67.9	20.8	41.6			
40				38 1	11.5	23.0	46.2	13.8	27.6	54.3	16.5	33.0	62.6	19.1	38.2	71.0	21.7	43.4	79.4	24.3	48.6
42							48.3	14.7	29.4	56.7	17.3	34.6	65.3	19.9	39.8	74.1	22.6	45.2	82.9	25.3	50.6
44							50.3	15.3	30.6	59.2	18.0	36.0	68.1	20.8	41.6	77.2	23.6	47.2	86.3	26.4	52.8
46							52.4	15.9	31.8	61.5	18.7	37.4	70.8	21.6	43.2	80.3	24.5	49.0	89.8	27.4	54.8
48							54.4	16.5	33.0	63.9	19.4	38.8	73.7	22.4	44.8	83.5	25.4	50.8	93.3	28.4	56.8
50							56.5	17.1	34.2	66.3	19.9	39.9	76.4	23 2	46.4	86.6	26.3	52.6	96.7	29.5	59.0

R.F.

NOTE.—For simplicity the amounts given above apply to silos with continuous doors. If intermittent doors are used, slightly greater amounts of material will be needed. The above table is based on a proportion of 1:2:4 for the walls and 1:2½:5 for the floor and footings.

writer firmly believes that every silo should be erected by a contractor who is familiar with this class of work. There have been failures of concrete silos in the past and the opponents of this form of construction have not hesitated to use these instances to the best advantage in inviting public condemnation of concrete.

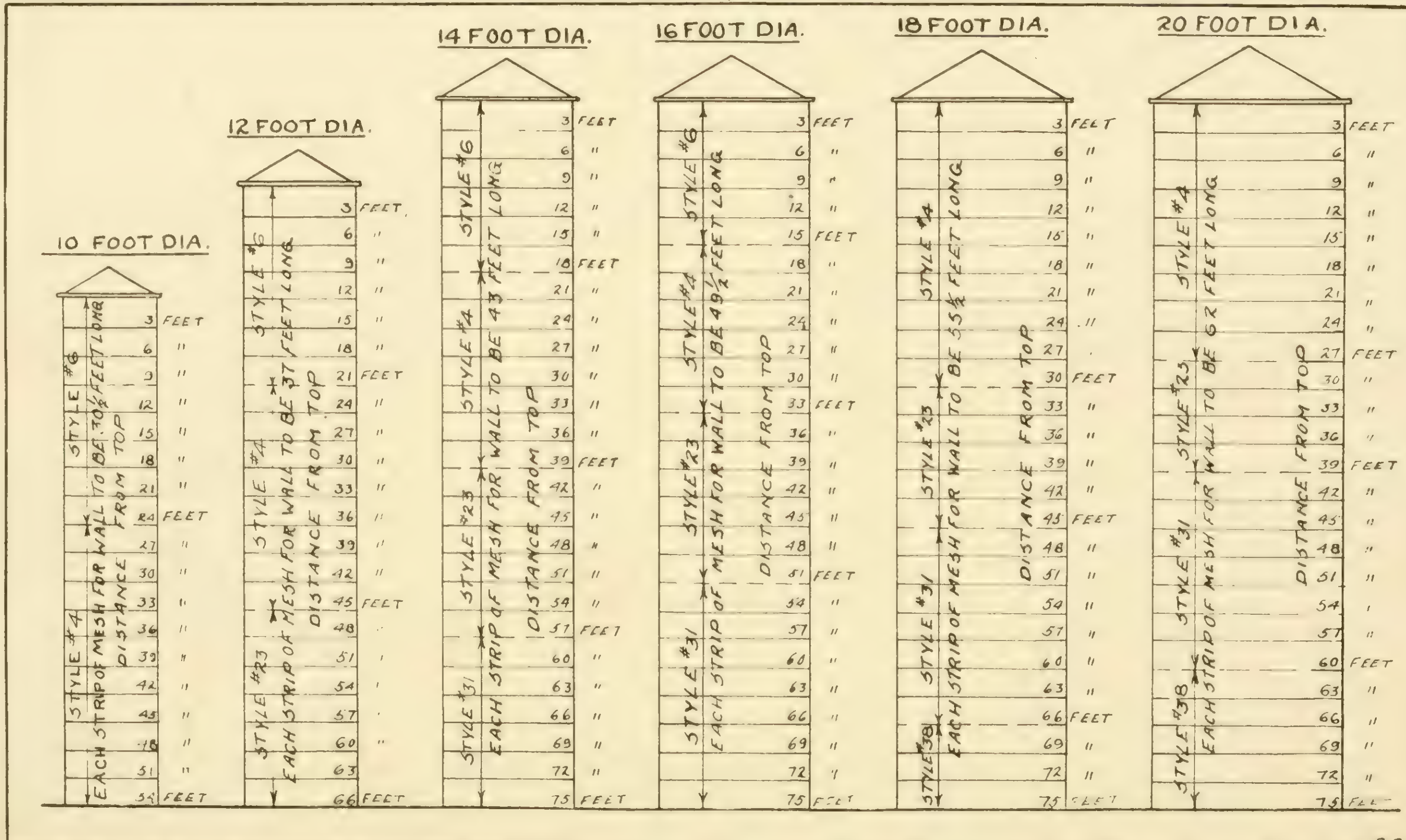
It is absolutely necessary for the benefit of the industry that no more such failures should occur; and one of the best expedients for preventing their recurrence is to allow only an honest and experienced contractor to put up a concrete silo. Such a contractor will scarcely care to bother with making his own forms, which at best will be awkward and inefficient, especially in view of the fact that there are on the market a constantly increasing number of commercial forms, and that the manufacturers of these forms are continually improving them and adding to their efficiency for construction.

A home-made form will perhaps build a dozen silos at best, when it has to be discarded and replaced. It is a makeshift proposition, cumbersome and inefficient, difficult to handle and inexact in its alignments. A properly built commercial system, on the other hand, will last at least for several seasons of work, is conducive to rapidity and economy of construction, and shows a finished structure which is exact in every detail.

In employing a contractor to build a silo, the farmer can, of course, have it understood that he is to supply the materials if he has them on his farm, or that he is to do the hauling, furnish some of the unskilled labor, or assist in any other way of which he is capable.

Another advantage in having this kind of work done by a contractor is that the contractor will have a

TABLE VI.—REINFORCEMENT WITH TRIANGLE MESH FOR VARIOUS HEIGHTS AND DIAMETERS.



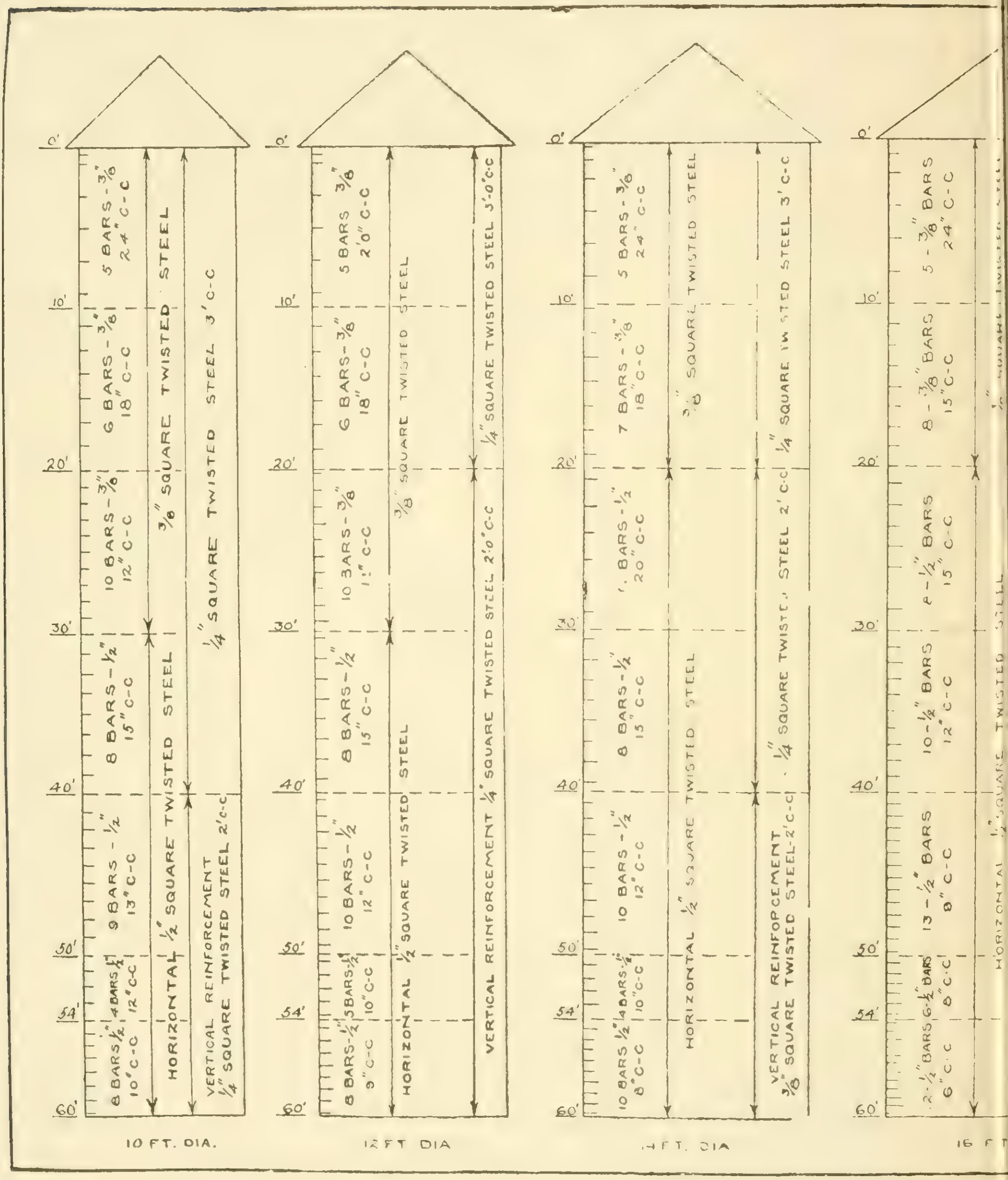
concrete mixer on the job, while the farmer himself would frequently be satisfied to mix the concrete by hand. On a structure such as a silo, which is built with a comparatively thin wall, and which at the same time has to withstand considerable strain, it is of the utmost importance that the concrete should be well mixed, so that it may attain its greatest strength.

For the same reason, too, considerable care should be given to the materials, making sure that they are clean and properly graded to make a concrete of the greatest density. Sand and gravel for silos are as often as possible secured from deposits in the locality, rather than being bought from commercial plants, and hence need most careful inspection. Gravel taken from a creek is often coated with clay loam, which prevents the cement from making a good union, and very often it contains particles that are too large or of a crumbling character. Such gravel should be run over a screen and washed before using. Soft granite, shale, slate rock or dusty cinders are not desirable. The material should not easily crush and disintegrate and should be suitable to give a good, strong union with the cement. Above all it should be repeated that it should be absolutely clean.

In some localities there are natural deposits of gravel containing varying proportions of sand. If clean and not too coarse, such gravel is well suited for silo building; but in using this material it is never safe to assume that the proportion of sand to gravel is correct until a quantity has been run over a ¼-inch screen and the exact proportions determined. Usually such gravel contains too much sand.

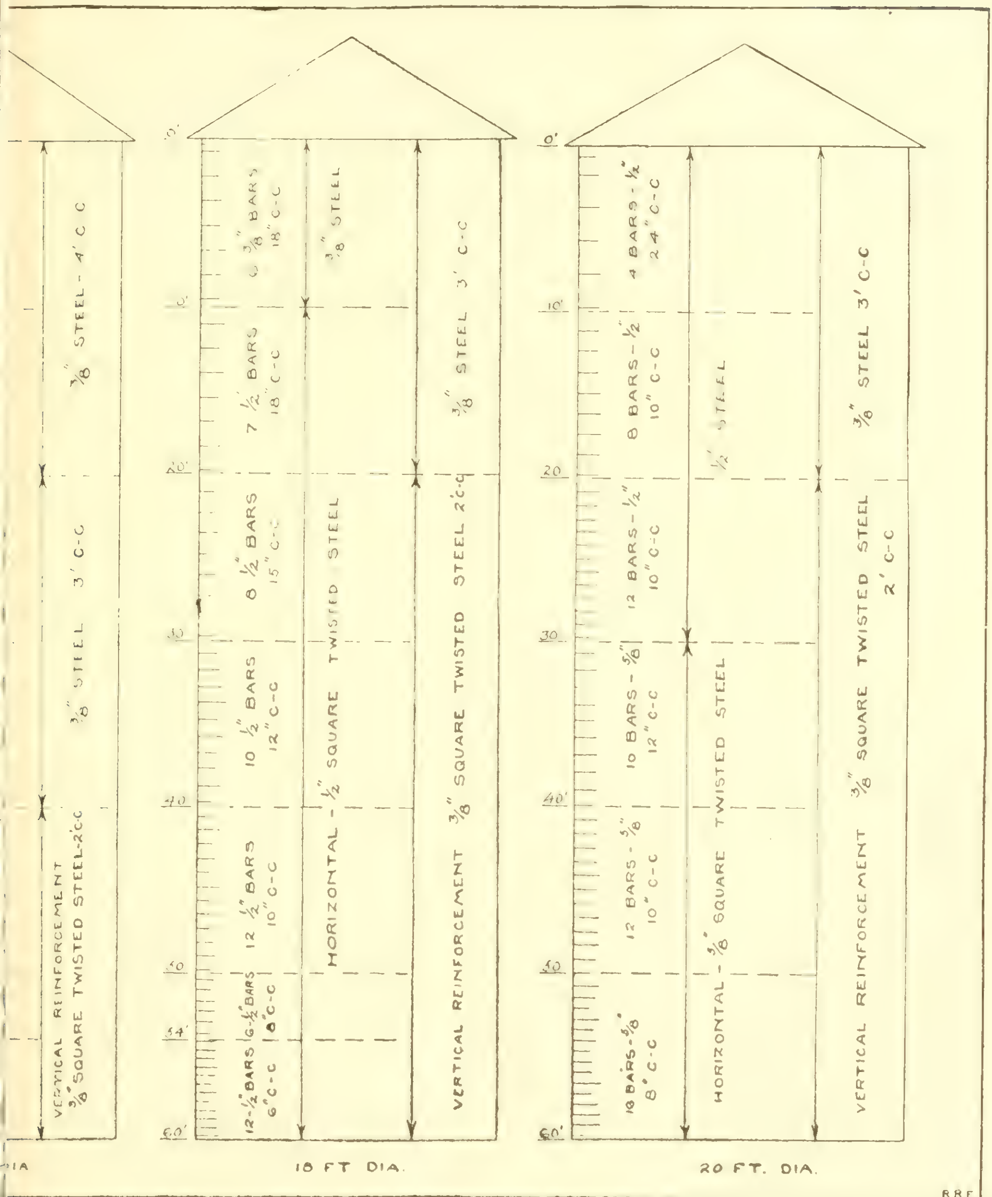
For the foundation the stone may be as large as will pass through a 2½-inch ring, while for the main

TABLE VII.—AMOUNT OF REINFORCING IN TWISTE



This Table, Which Is Adapted From Tables Compiled by the Reic
in Height. For Silos of Less Height, Cut Off the Diagram at the Figur
Line, Using the Steel Calle

STEEL BARS FOR SILOS OF VARIOUS DIAMETERS.



t Manufacturing Company, Shows Reinforcing for Silos Up to 60 Feet Indicating the Desired Height, and Disregard Everything Below That r Above the Line.

wall of 6-inch thickness the size should not exceed 1½ inches. A mixture of particles of various sizes from ½ up to 1½ inches makes the strongest wall.

The water used for mixing concrete should be clean and free from alkalis and acids. It is especially desirable to caution builders of farm structures on this point, because drainage water from the barnyard or water from a muddy stream may sometimes find its way into the supply.

The usual proportions for a 6-inch concrete wall are 1 part of cement to 2 parts sand and 4 parts stone.

In filling the forms, only a few inches in depth should be filled in at one place at a time. Depositing a great quantity of concrete at one place puts a heavy strain on the forms and has a tendency to force them out of plumb. As the concrete is put into the form it should be spaded with a piece of 1 by 3 inch board, sharpened to a bevel edge. The purpose of the spading is to remove all air bubbles and avoid the formation of cavities. On the other hand, in a wet mixture as used in silo building the spading must not be overdone, or the heavier rock will sink to the bottom and the cement and water will rise to the top.

The exterior surface can be kept smooth by greasing the outside form with soap or some cheap oil or grease. To be effective this grease coat must be renewed at each raising of the forms. No grease should be used on the inside form, as this surface is to receive a brush coat of pure cement wash. Small particles of cement will adhere to this form each time it is raised, and before it is used again these should be removed with a broom or a wooden trowel. If these are not removed an undue amount of concrete will adhere, and this will result in an unnecessarily rough wall.

Showing the Difference Between a Silo That Is Brush Coated and One That Is Not.

As the forms are raised the fresh wall is constantly exposed to the drying air and sun, and there is danger of the surface drying and curing too rapidly for the interior of the wall, causing cracks. To prevent this the wall should be soaked with water several times a day for several days and when possible the wall should be protected with canvas or burlap thoroughly wet.

When the forms have been filled for the day do not smooth the top with a trowel, but leave it as rough as possible. A good plan is to roughen the top surface just as the concrete starts to set. Before putting fresh concrete on this wall the next day, the top surface should be soaked with water and then sprinkled with raw cement, which will help in making a good union between courses. The forms must not be removed for at least 5 hours after filling.

A brush coat of cement wash may be applied as soon as the form is raised and before the wall has had a chance to dry. This coat of cement helps to make the wall less porous and therefore more nearly air and water tight. The wash is prepared by mixing together cement and water to the consistency of thick lime whitewash, and is applied with a whitewash brush in the ordinary way. If the wall has had time to dry it should first be drenched with water.

After this coat of cement wash has been applied the whole interior may be painted with coal tar thinned with gasoline. The coal tar makes the wall impervious and also protects it from the action of acids which develop in the silage. It should be renewed from year to year as may be required. The application of the coal tar may be left until the wall is complete, but should be done before removing the interior scaffold.

CHAPTER IX.

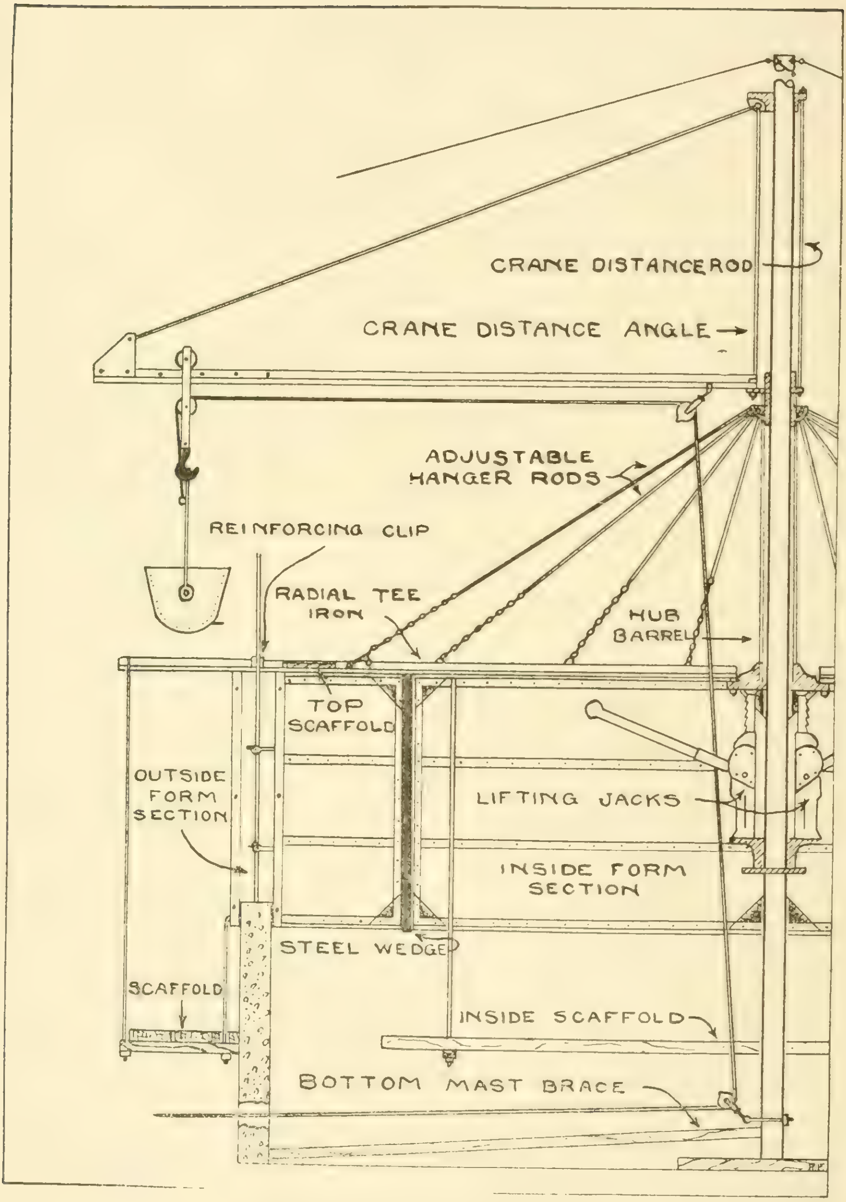
The Polk System.

This system of silo construction is controlled by the Polk-Genung-Polk Company of Fort Branch, Indiana. It has as its basic principle of operation a center mast, erected at the center of the floor of the structure and carefully plumbed by means of guy wires attached to the top and provided with turn-buckles. From this mast everything used in the construction of the silo is suspended, including the staging, the apparatus for handling the forms, and the crane for hoisting and depositing the concrete.

The mast is a four-inch steel pipe, provided with a series of transverse holes to receive a heavy steel pin. This pin supports a widely flanged collar, which serves to support the jacks by which the forms are lifted.

Resting upon the jacks is a hub, consisting of a flanged base collar and a top dished collar connected by a central pipe of sufficient diameter to work easily over the center mast. From the base collar of this hub radiate steel tees which are supported from the upper collar by adjustable hanger rods with chain clevises.

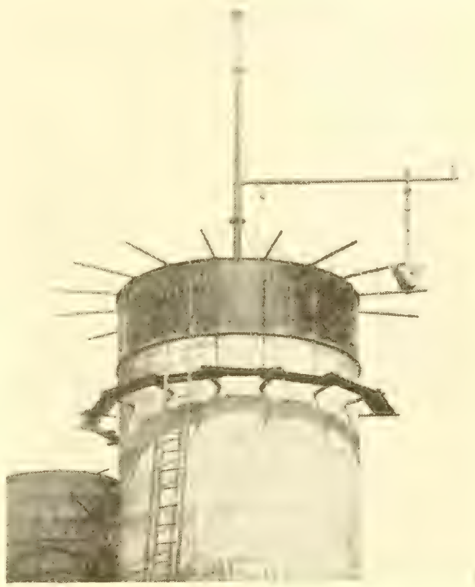
Each form consists of eight separable sections, and each section is reinforced and stiffened by a steel angle frame around the edges. The inner and outer steel wall-forms, which are rolled to the required curvature, are bolted to the radiating steel tees. The outer sections are bolted together at their ends through holes in the frames. The inner sections are similarly bolted together, but carry steel wedges between them, the



The Polk System Equipment

lifting of which allows the inner sections to swing free.

To keep the vertical reinforcing in its proper position in the center of the wall, small steel clips are provided. The vertical reinforcing passes through these clips, which fit over the stems of the steel tees.



Polk System Machine in Operation

For placing the concrete between the forms, a V-shaped dumping bucket is provided. This bucket is supported by a crane pivotally attached to the center mast directly above the top collar of the hub, and can be easily swung to any part of the wall space. It is hoisted by means of a rope and series of pulleys so arranged that the hoisting force is applied horizontally from without the structure. A small opening, through which the hoisting rope works, is cut in the wall near the bottom of the first fill of concrete. When the bucket is hoisted it is coupled to a carrier on the crane by means of a hinged hook and is then swung to any part of the wall space desired.

The scaffolding, both inner and outer, is swung from the steel tees, which project some distance beyond the wall.

The operation of the machine is very simple. The forms are set, the reinforcing bars are placed in position, the concrete is mixed, hoisted, dumped and packed between the forms, and allowed to set. The next morning the nuts connecting the sections of the outer form are loosened, the steel wedges fixing the sections of the inner form are lifted, and both inner and outer forms swing free from the wall. Then, by means of the jacks resting on the widely flanged base collar, the whole mechanism is lifted until in position for a new fill and the forms are again set by means of the bolts and wedges. One fill a day is the customary rate of progress.

These silos were originally made without chutes, but a chute form is now an integral part of the system.

Twin Silos, 16x72 Feet, at Dayton State Hospital, Dayton, Ohio

This chute form is carried by two of the steel tees which are longer than the rest and is attached to the outer set of shells, taking the place of one of the separable sections. It is set to maintain the continuity of the silo wall and to mould a chute wall of a thickness of 6 inches where it joins the silo wall, gradually decreasing to 4 inches at the outside. The outer shell of the chute form is released and bolted up in precisely the same manner as the outer form of the machine is released and bolted up, the outwardly curved sections forming the wall immediately adjacent to the silo wall proper being attached to the regular outer form sections. The inner form is released and set by means of a steel wedge similar to those used between the sections of the inner shell proper.

Provision is made for the forming of doors opening into the chute and for the construction of a steel ladder inside of the chute. Reinforcement for the chute is handled as in the silo wall.

The elliptical openings which are formed for the doors are 20x30 inches. They are usually spaced 24 inches apart, but the number and arrangement of doors are optional with the builders. The elliptical shape has been chosen in order to avoid sharp angles. For the formation of this opening a sheet steel door is set between the shells of the machine as the work progresses. This form moulds a concrete jamb 1 inch in width and ½ inch in depth from the inner surface of the wall. Owing to the shape and draft of the form the jamb is left in perfect condition for sealing the door. Immediately after the machine has passed the opening the door form is removed.

The door itself is made of heavily galvanized sheet steel, cut to fit snugly into the concrete jamb made by the form, flush with the inner wall and bent to the radius of the silo. On the outside of the door are fastened four malleable clips in which hook bolts engage. Across the opening on the outside of the silo wooden bars are placed through which these bolts pass. The desired stress is obtained by malleable tail nuts. In sealing the door a thin gasket of moist clay is smeared around the jamb before the door is set in place.

The silo ladder is made of $1\frac{1}{4}$x$1\frac{1}{4}$x$\frac{1}{8}$ inch steel angle runners and 1x1x$\frac{1}{8}$ inch steel steps, the joints being electrically welded. It is secured to the concrete wall by strap screws which are screwed into spiral steel anchors imbedded in the wall during construction. When the wall is completed the temporary fillers in the anchors are removed and the strap screws are firmly inserted. The ladder is then bolted to the strap screws and is ready for use. Ordinarily the ladder is made up in 10-foot lengths, but sections of any length may be cut.

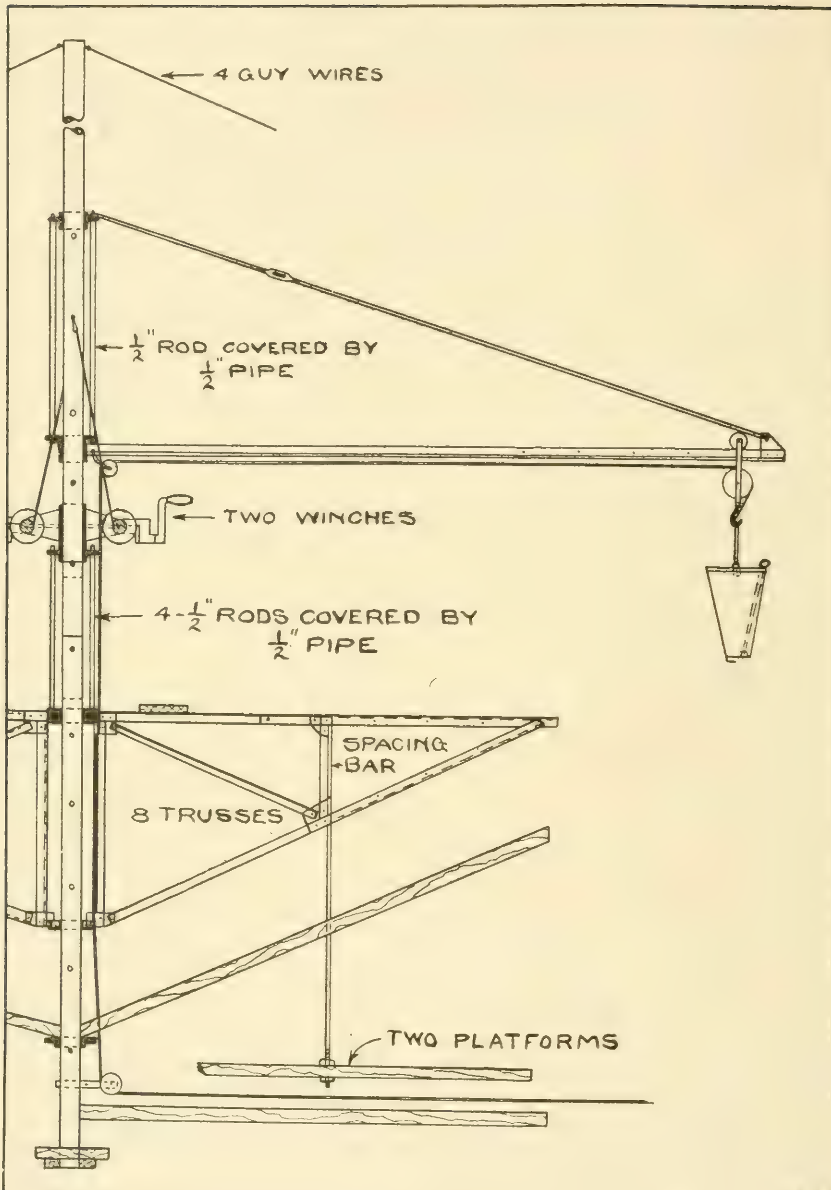
CHAPTER X

The Monsco System

This is a system of construction with metal forms controlled by the Monolithic Silo and Construction Company, Chicago. These forms are made of No. 16-gauge galvanized sheet steel and are held true to shape by curved steel angle irons welded to the sheet, which reinforce the steel plates at the edges and through the middle. The forms are made in sections 3 feet high and the circumference of the silo is divided in 5 to 8 segments, according to the size, this including the form for the chute, which, if desired, is cast at the same time as the walls of the silo. Sufficient forms are used in an outfit to form two complete circles around the silo.

In starting the construction of the walls, one circle of these forms is placed on the foundation and poured full. The next circle of forms is then clamped to these and poured. This 6 feet will usually constitute a day's work. The next morning the bottom circle of forms is raised to the top and filled, after which the section below is raised and filled, this constituting the second day's work, and the operation is repeated until the desired height is reached. In other words, the operator is always pouring into a 3-foot section of mold firmly clamped to another 3-foot section filled with concrete, the concrete set sufficiently to eliminate the possibility of a wall fracture.

These silos have 6-inch walls, the thickness being the same from top to bottom. Forms are made for diameters of 10, 12, 14, 16, 18 and 20 feet.

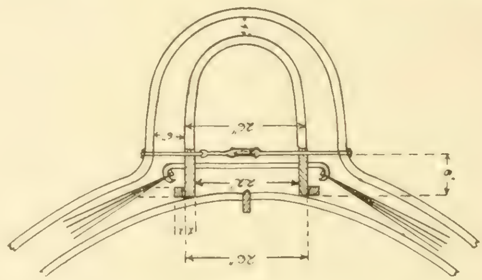


Equipment for the Monsco System.

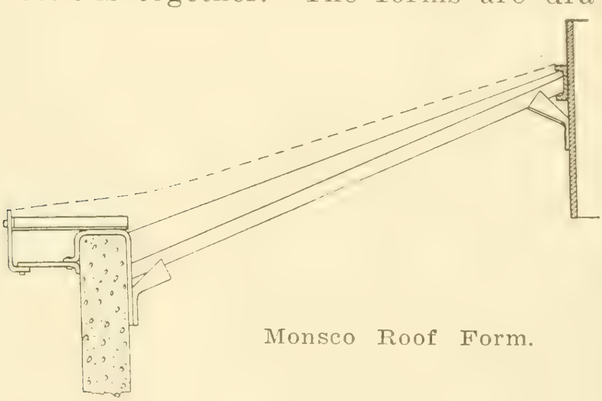
Completing a Monsco Silo.

The construction is carried on by means of a center mast of steel, this mast carrying a steel frame for staging and also a revolving derrick carrying the buckets, by means of which the concrete is elevated and deposited. The elevation on the mast of both the staging and derrick are under control of the men on the staging, so that they can be readily moved up as the construction proceeds. The mast and staging frame are entirely separate from the wall forms, the latter depending entirely for support on the 3 feet of wall when closed by the lower circle of forms; and as the upper section of the staging frame is always above the wall forms the same outfit will, of course, answer for varying diameters of silos.

These silos are reinforced with triangle mesh reinforcing, the selection of the reinforcing depending upon the size of the silo and being selected usually to provide sufficient strength without placing any additional wires. The company recommends a 38-inch width, this allowing a 2-inch lap between courses. After a circle has been poured and it is desired to move up the lower section of the forms, the bucket at the end of the derrick is taken off and a wooden seat is suspended from the hook in its place. By this means a man is lowered to the outside of the forms and removes the clamps which hold the two sections together. The forms are drawn up by men on the scaffold by means of hooks which engage in holes in the angle iron welded to the top of the forms. The inside forms are manipulated



Section of Mold at Chute.



Monsco Roof Form.

from a small auxiliary platform suspended below the main platform of the scaffold. As the construction is carried up, the mast is raised by means of two cast-steel worm-geared winches.

The door on this silo is of the continuous type. It has a gas pipe running through the concrete on each side, and around which the ladder irons are engaged. The gas pipe has several strands of wire extending around it at frequent intervals and running back into the concrete 2 or 3 feet in order to provide a sufficient anchorage. The doors themselves are of wood.

A special roof form, making a concrete roof, with dormer, is also supplied if desired.

CHAPTER XI

The Reichert System

This is a system of monolithic construction developed by the Reichert Manufacturing Company of Milwaukee. It differs from other systems of this type in that the forms are made in sections 24 inches square, instead of in larger sections, so that each can be handled easily by one man. The small size also makes for adjustability, a feature which is still further provided for by the fact that the sections are reinforced at top and bottom with strap steel instead of angles, thus allowing them to take the curvature of the particular size of silo under construction, to which they are then held by a rigid inner steel circle and by spacers placed at suitable intervals. Silos of all diameters are thus made with the same outfit, except that fractional plates have to be used to fill out for the various sizes where the circumference does not work out in exact multiples of 24 inches.

An outfit consists of sufficient forms for three rings around the silo. This is enough for one day's run, or 6 feet in height, the practice followed by most contractors in using this system, although some are erecting 8 feet per day.

The sections are reinforced vertically with angle irons, and when assembled the vertical joints are secured by clamps. These clamps are attached to one angle of each section and when in place fit down over the angle of the adjoining section, a push of the lever driving them up tight. These levers are downward acting, so that when it is desired to release them a jerk with the hook from above is all that is necessary.

Each section is joined to the one above it by a hook attached to the upper edge of the lower section, which hooks over a raised rivet on the lower edge of the section above. This hook is pivoted and has a hole in the shank, so that a workman above, after raising the side clamps with a long hook, which is a part of the outfit, can insert the point of the hook in the shank of the hook on the lower form, with one operation disengaging the form from the one above it and drawing it up into its new position.

Reichert Silo With Square Chute

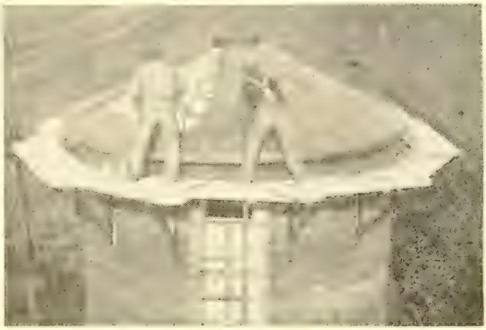
There is in this system a center mast of steel tubing, carrying collars which can be moved up as the work progresses and to which the radial staging arms are attached. There are two sets of these arms. The upper platform is flush with the top of the silo, from which the forms are manipulated and the pouring is done. Each of these arms consists of two angle irons telescoped on each other and with bolt holes at suitable intervals, so that they can be adjusted to the various diameters it is desired to build. At one end they rest in slots in the collars on the mast, and at the other end they rest on the circles of angle iron which are carried right up with the forms to give them their true shape. These circles are made in segments for easier handling, but can be rigidly clamped together for use.

The upper ring, which holds the forms in shape, also carries a single track on which run the two wheels of a small car. This car rests on a frame attached to a loose collar around the mast and just above the collar which carries the upper platform. It thus can be pushed around to any part of the circle desired, swinging around the mast as a pivot and the outer end carried by the wheels on the track. This car is merely a frame with bearings on which the bucket of concrete can be set when it is brought up from below, the arrangement being such that it can be tilted to dump into the forms, a steel apron being attached to the car to direct the flow into the forms and prevent loss of concrete.

A derrick, also attached to the mast in the center, by which all materials are handled, completes the outfit.

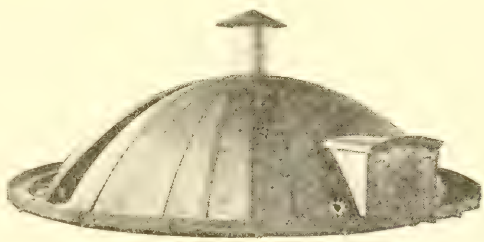
The ordinary wall thickness in this system is 6 inches, though the adjustability is such that almost any desired thickness can be obtained, the only additional parts of the outfit needed being spacers for the desired thickness and perhaps additional fractional plates in order to make the outside ring fit the change of circumference.

Two types of chute are provided for: a square chute is made with the ordinary flat wall sections made by the Reichert Manufacturing Company, or a curved chute made with special sections provided for the purpose. This system contemplates the use on a continuous door, and door frames are provided with the outfit, to be set into the forms. They are slotted to carry the ladder irons. Intermittent door forms can also be supplied if desired.



Completing a Conical Roof

Reichert metal roof molds are made in two types. One of these is a dome roof, the form consisting of curved segments which rest on the silo wall proper and are locked to a hub at the top. The angles of the separate sections fit into slots in the hub, thus locking the entire equipment together. The other type of roof consists of straight segments resting on the side walls and bolted to a ring at the top. The roof molds include complete equipment for making cornice and dormer window. No part of the mold is left in the structure, all being taken away and used repeatedly.



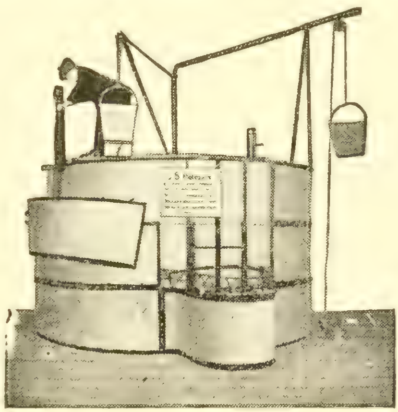
Form Assembled for a Dome Roof

The reinforcing used in the Reichert silos is either Triangle mesh or square twisted steel bars. The mesh is used according to the table of the American Steel and Wire Company, as given on page 66. The bars are placed according to individual plans for each size as drawn up by the Reichert Manufacturing Company. Table VII, on page 68, gives in somewhat shortened form the scheme of reinforcing with bars as used by this company.

CHAPTER XII

Other Monolithic Systems

Peerless Silo Molds. These molds are controlled by the New Enterprise Concrete Machinery Company, First National Bank Building, Chicago. They are made of sheet steel, reinforced with iron frame, and are sufficiently flexible so that various diameters of silos can be made with the same forms by using smaller plates to bring them to the proper circumference. The inside form is a No. 16 steel and the outside form is a No. 18. The chute is poured at the same time as the main body of the silo wall.



Peerless Outfit.

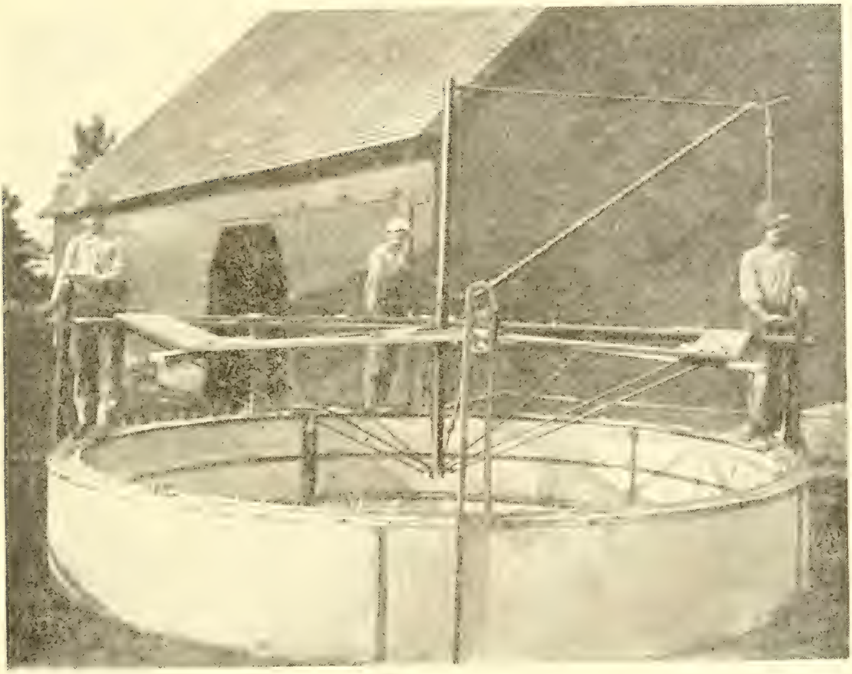
The unusual feature of this system is the combined derrick and scaffold which rests upon the concrete wall, doing away with the necessity of building up staging from the ground. The derrick and staging are raised by four small jacks or raising devices, stationed at the quarter points of the circumference, with a man at each jack. By this means the derrick-scaffold is raised first, before the forms are drawn up into place.

These molds have a daily capacity of 5, 6, or 7½ feet, depending on the number and type used. The 6-foot molds are made in two rings of 3 feet each. The

Peerless Silos at State School, Lincoln, Ill.
Dimensions, 17x50 Feet.

usual custom at present, however, is to use 3 rings of $2\frac{1}{2}$ feet each, thus building $7\frac{1}{2}$ feet of wall each day. Molds are built for a 5-inch wall unless otherwise preferred.

Triangle mesh is used throughout for reinforcing. Metal doors and door frames of the continuous type,



Peerless Outfit. First Ring of Mold Filled and Derrick Raised to Receive Second Ring.

and either metal or concrete roof are included in the construction of these silos.

Martin Adjustable Steel Silo Forms. These forms are made and sold by the Martin Concrete Form Company, Ottawa, Kan. They build silos from 12 to 20 feet in diameter.

The outside form is made of 14-gauge steel and the inside form is made of 12-gauge steel. The top and bottom of the inside form are held in place by angle iron braces radiating from the center. Each section of the inside form is adjustable to a larger or smaller circle by means of turnbuckles. The size of the form is also changed by adding sections and adjusting the curvature of each section. The ends of each section are made with slideable edges and are provided with turnbuckles for contracting and expanding the forms.

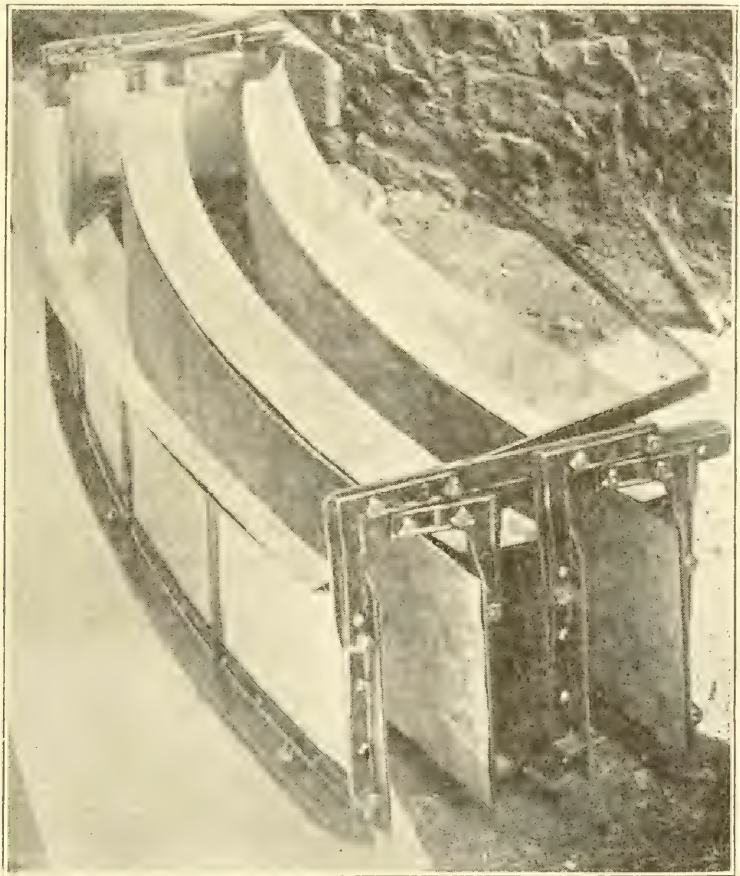
The form is raised by means of jacks operated from the platform. The reinforcing rods run through the jacks. At the bottom of the jack is a collar clamped to the reinforcing rod which supports the jack. The extension yoke which is attached to the inside and outside form is bolted to the stationary nut of the jack. By turning the screw the nut is pushed up, pulling the form with it.

These forms provide for building 6 to 10 feet of wall in height per day.

Building a Silo with Martin Forms

Intermittent metal doors are used in this system. They are 20x22 inches in size, and are made entirely of cast iron except the hinges, which are mild steel. The frames are also of cast iron, and carry a groove for felt packing. They are set into the forms as the concrete is poured.

Van Guilder System. This system, which is controlled by the Van Guilder Hollow Wall Company,



Van Guilder Hollow Wall Form

Rochester, N. Y., makes a silo with either a single or a double wall. Either type is made with a small machine, as shown in the illustration, which is set on the footings tamped full of concrete, then removed and carried around to a new position, the operation continuing until a complete circle has been made. The machine is then set on the section of wall thus made and another section is carried around in the same way. The double wall machine makes a 4-inch air space and the walls are adjustable for thickness of from 4 to 6 inches. The single wall machine can be adjusted to make walls from 5 to 8 inches thick. The machine is not adjustable to different diameters of silos.

The Conklin System. Made by the Conklin Construction Company, Hartford, Mich. The molds are of No. 16 black sheet steel held in shape by 1½x1½ angles riveted on. The inside forms are also reinforced with 1½ inch channel steel in the center to keep them from buckling. The forms are made in sections 4 feet high, and two complete circles constitute an outfit, sufficient for a day's work of 8 feet of wall.

The hoist is operated on a center mast of a 4-inch gas pipe and in 10-foot lengths with slip joints. One-inch holes are drilled at proper distances through the center mast for 1-inch pins. The jack bench and spider hub rest on the pins through the center mast.

There are eight tee irons radiating from the spider hub and supported by rods and chains from the casting above. The rods and chains are adjustable. On the ends of the tee irons are adjustable tee irons or arms that may be taken up or let out for the different sizes of molds. Boards are laid on the tee irons to make a scaffold for the men to operate the machine.

From every other tee iron are suspended ⅝-inch rods (4 in all) to hold two timbers (2x6 inches), on which a scaffolding is built completely over the inside of the silo. The men stand on that scaffold and do their work inside the job.

The boom is supported by two ⅝-inch rods with turnbuckles which swing around the center mast. It carries a car or traveler which carries the hoisting cable and cement bucket.

The derrick is also used as a means of support for the workman who uncouples the outer forms when they are moved up.

A sufficient area of steel is provided in the cross wires of triangle mesh reinforcement to prevent temperature cracks, thereby eliminating the necessity of laying additional reinforcement at right angles to the longitudinal or tension members. The common width is 54 inches. This allows for a 6-inch lap on each 4-foot section poured.

The Conklin silos are equipped with continuous doors, 30x30 inches, of 1-inch lumber, with tar paper between, with felt gasket between door and cement. The doors are set in a 2-inch cement jamb, forming a solid construction. Ladder irons are placed about every 30 inches, made of 1-inch mild steel.

The Conklin equipment is adapted to build the non-continuous type of doorway by leaving out the steel forms for blocking off the continuous doorway and adding the special form in the chute for making the non-continuous. By using this special form, any style of door (elliptical or square) can be used, by placing the door form between the special chute form and the inside silo form.

The 2-E Flexible Silo Form. This form is 5 feet in length and build either a hollow or solid wall. In building the silo the form is placed on the foundation and filled and tamped, then moved to a new location and filled again, the operation being repeated until the entire circle is completed. The courses are 10 inches high. The form is sold by M. L. Schluetter, 223 West Illinois Street, Chicago.

Blumer's Perfect Silo Forms. These are galvanized iron forms reinforced with angle irons and made in large segments so that two or three large sections, possibly with a small filler, will make a complete circle around silo. Bracing rods are attached to the inner sections, across which plank may be placed for workmen to stand upon while drawing up sections or filling in with concrete. These forms are sold by St. Jacobs Lumber and Hardware Company, St. Jacobs, Ill.

CHAPTER XIII

The Pit Silo

Instead of being built above ground, as is the ordinary fashion, a silo may consist of a hole excavated in the earth and plastered with cement mortar. This is known as the Pit Silo.

This type of silo has apparently but one advantage, and that is the advantage of cheapness. A pit silo is not to be considered as a permanent improvement. If it is necessary to put in a temporary expedient, however, as is the case of a tenant on a farm, who would in many cases not be justified in going to the expense of building a permanent silo, the pit silo will do very well. In fact it will fulfill its purpose much better than the wood silo, the only other type of construction which would be considered under such circumstances, and is usually much cheaper as well.

It must be borne in mind, however, that it is not practicable to build pit silos in all localities. They can be built to advantage only in soil which has a low water level, so as to preclude the possibility of dampness in the silo.

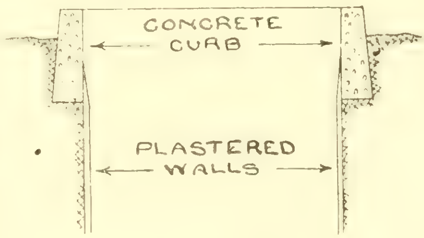
The depth of 20 feet is considered about the limit of practicability for such a silo in any event because of the difficulty of removing the silage; but it should not go to this depth if there is a possibility of striking water. Of course it would be possible to seal a structure effectually against moisture, even at a considerable head; but this would be an expense which such a structure would not justify, it being much better to expend the money on an above-ground silo.

While silage will keep very well in a pit silo if the silo is made moisture proof, there is one insurmountable objection to this form of silo as above suggested, and that is the difficulty of getting the silage out. The advocate of this form of construction will say that this is offset in a measure by the ease with which the pit silo is filled; but when it is considered that the filling is done in favorable weather, while the silage is removed during the winter, this does not constitute as great an offset as might at first appear. Furthermore, there is a tendency in constructing the pit silo to rely entirely too much on the stability of the ground, simply giving a plaster coat to form a smooth interior wall. This plaster will crack sooner or later, depending on the condition of the soil; while, if the builder goes to to the trouble of preparing an inner form and pouring a substantial monolithic wall, this expense, added to the cost of excavation, will show little gain over an above-ground silo.

In the case of pit silos it must also be remembered that there is a possibility of carbon dioxide gas collecting in the bottom and making it dangerous for persons to enter. This gas is apt to form in larger quantities within a day or two after the filling begins, so that if it is necessary to partially fill the silo and then let it stand for a time, a lighted lantern should be lowered into the pit before entering it. If it is found to contain gas, running the cutter for a few minutes and emptying its contents into the silo will usually set up a sufficient current of air to carry the gas away.

There are three types of pit silos: Plain holes in the ground, where the walls are plastered and the silage is cropped in and lifted out at the top; holes in the ground, but with the silo extended above the ground from 4 to 12 feet, the roof placed above this, and the silage removed through the side of the upper part; silos built similar to either of the other two, but set in the bank so that retaining walls which act as a chute are placed up and down beside a line of doors. If there is a bank barn and the retaining walls connect the silo to the barn, the conditions are ideal.

Of the three types of pit silos mentioned above, the last is the most convenient, also the most expensive. The first is the cheapest and likewise the least convenient.



Section Through Pit Silo

Most silos are constructed by commencing at the bottom and building up; but a pit silo can be constructed by commencing at the top and building down. By building a silo in this manner, the ground acts as a staging and no lumber or labor is required for that purpose.

The first step in the construction of a pit silo consists in affording sufficient protection to the edge of the excavation to prevent crumbling or caving. An exact circle should be marked out on the ground of the size of the proposed excavation. Immediately outside of this circle a trench should be excavated not less than 18 inches deep and not less than 1 foot wide. This trench should be filled with concrete properly made. As soon as the concrete in the trench has set and sufficiently hardened the excavation may be proceeded with.

A hay carrier track should be arranged above the proposed excavation at sufficient height so that the dirt from the carrier may be dropped into a wagon placed for the purpose of receiving it. This track should have an upward slope toward the wagon so that when the carrier is unloaded it will return of its own weight to the stop, which should be placed exactly above the middle of the silo.

The carrier is best made of a strong box with a hinged bottom, with a fastening that may be easily secured and easily loosened. This may be attached to the hay carrier by chains or ropes so arranged that the box when loaded will balance. A horse on the end of the tackle rope or a gasoline engine with a lifting appliance will do the lifting. When this appliance is arranged in a satisfactory manner it becomes an easy matter to take care of the earth from the excavation.

The excavation should be made in such a way that the walls are perpendicular and smooth. When the excavation has been carried to about 10 feet (and this distance is chosen because experience has proved that it is most satisfactory for the purpose), the walls of the excavated part should be given a good coating of the best cement concrete mixture. This should consist of not less than 1 part of Portland cement to 2½ parts of screened sand. The sand should be sharp, not too coarse, and free from clay. The first coat should be left rough, and the second coat immediately applied before the first coat hardens. In order that this work may be well done, it is best to employ an experienced mason for this purpose. The first two coats should constitute a single coating not less than ¾-inch in thickness. When this coat has had sufficient time to harden enough to be protected against injury, the excavation may be continued to another depth of 10 feet, and the plastering repeated.

It is well to provide for some drainage at the bottom of the silo. This may be done in the following manner: When the excavation is finished the earth floor of the silo should slope toward the center. Here a hole should be dug large enough to receive a drainage tile 30 inches long of any desired diameter. The drainage tile should be inserted in this hole, and covered with an iron grating with a mesh sufficiently small to be a protection against rodents. The bottom should then be covered with cement in the same manner that the sides are covered, and this cement should join the grating and hold it in place. Any moisture that accumulates in the silo may in this manner be drained off, preventing both annoyance and waste.

For convenience, it is better, after the silo has been finished, to put a masonry extension above ground for a distance of at least 4 feet, with a door upon one side through which the carrier used in removing silage may pass. This extension may be built of poured concrete, providing forms can be made for the purpose, or it may be made of concrete blocks properly constructed, or of any material that to the builder seems most desirable.

A roof should be provided, and this should be made in such a manner as to allow the free use of the carrier and track that are used in removing the silage.

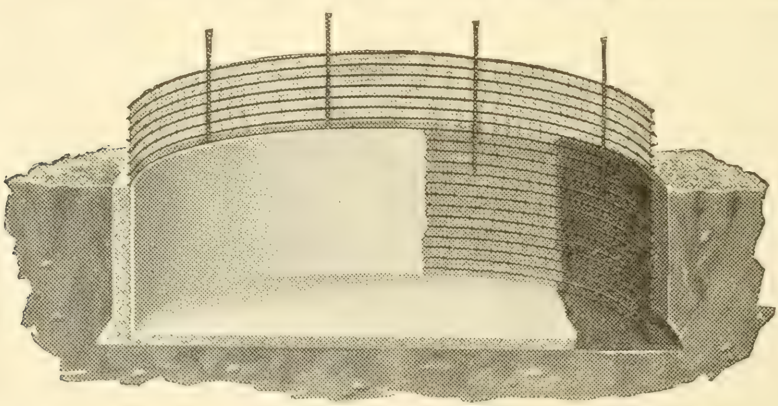
If it is desired to give the pit silo somewhat more stability than can be attained by plastering on the bare ground, a metal fabric can be used and the plaster coat placed on this. Stakes can be driven into the earth walls of the silo and the metal fabric fastened to these stakes.

CHAPTER XIV

The Metal Lath Silo

The construction of the metal lath silo has been treated in considerable detail by Mr. Geo. C. Wheeler, specialist in animal husbandry of the Kansas State Agricultural College, Manhattan, Kans., in an article published in a bulletin of that institution. This article has also been reprinted, with slight modifications, by the Northwestern Expanded Metal Company, of Chicago, and we can do no better than to follow quite closely the information there given.

The first round of the metal lath which forms the chief reinforcement of this silo must have its edge embedded 5 or 6 inches in the top of the foundation, in order to insure a perfect union between the foundation and the wall proper. When the footing trench has



Cross Section of Foundation of Hy-Rib Silo.

been filled to within about 6 inches of the top and the concrete brought to an approximate level, the lath, which comes in strips 8 feet long and 18 inches wide, should be stood on edge on this base and concrete should be poured on both sides of it. Its position should be on a circle having a radius 2 inches greater than the inside radius of the finished silo. The strips of lath should be lapped abcut 3 inches at the ends. When the circle is completed, the wall outside of the lath should be carefully leveled. In eight or ten hours the dirt inside of the foundation wall may be thrown out to within 10 or 12 inches of the bottom of the concrete.

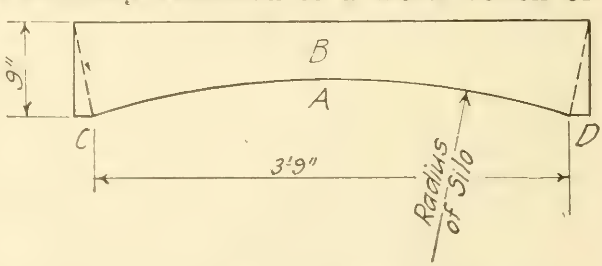
In building this type of silo it is necessary to erect on the inside a scaffold of at least four platforms before any other work can be done. It is very important that this scaffold be so constructed that the plank runways of the four platforms shall be at a uniform distance from the wall of the silo. In silos 14 feet or greater in diameter, a six-legged scaffold is used. For a 12-foot silo a scaffold of only four legs is needed. In order to place this scaffold properly there should be marked on the floor of the excavation a circle having a radius 2 feet less than the radius of the silo. The six legs of the scaffold, granted that a six-legged one is to be used, should stand on this circle and should be equidistant from each other. The distance will be equal to the radius of the circle upon which they stand; the sweep used in marking this circle may therefore be used as a measure, marking the place for each leg to stand on the circle until the six points are located. It will be much more convenient to have the door opening of the silo come between two legs of the scaffold than directly opposite one.

All the crosspieces should be of 2x4 material and of such length as to extend at least a foot outside the legs of the scaffold. The planks to form the runway on the outside should be of 2x8 material, and in a silo 16 feet in diameter should be 8 feet long. If the silo is to be 36 or 37 feet high, it will be necessary to make five platforms. It is convenient to have the top platform come within 3 or 4 feet of the top of the silo, since the work of raising the 2x4's and nailing the plate on top is done from this platform.

The following table shows dimensions of plate segments and number required for silos of different sizes:

Inside diameter of silo	Dimensions of segment C. D.	No. of segments required	Radius
12 feet	2 ft., 10 1/2 in.	26	6 feet
14 feet	3 ft., 4 1/5 in.	26	7 feet
16 feet	3 ft., 10 in.	26	8 feet
18 feet	3 ft., 9 in.	30	9 feet

The plate is sawed from 1x6-inch material, which should be either fir or cypress. The plan of making the pattern is shown in the plate. A piece of the 6-inch board should be securely fastened to a work bench or barn floor, and after the distance C-D has been determined from the table, these

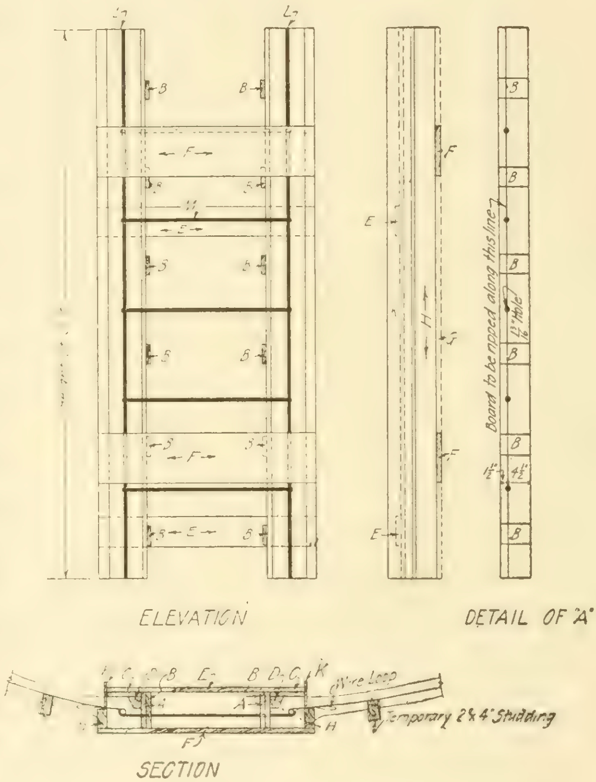


Detail of Plate.

points should be carefully marked upon one edge of the board. Locate the center of the desired curve by the use of a sweep, through which two small nails have been driven, the distance between them being exactly the inside radius of the silo. Using C and D as centers, describe intersecting arcs, thus locating the desired center. Drive one nail of the sweep at the intersection of these arcs. With the other nail mark the curve on the 1x6-inch board. With a straight-edge, extend the radius across the board, locating the lines at ends of board for sawing off, as shown by dotted lines in the plate. This pattern should be carefully sawed out and used in marking out the rest of the segments necessary. These plate pieces are to be doubled and the joints broken as the plate is built up.

In order to cast the posts or door jambs for the continuous door opening used in this type of silo and to properly hold the reinforcing in place, a form must be constructed extending the full height of the silo above the foundation. One of the plates gives the details of construction of this form. The 6-inch boards should be scribed the full length, 1½ inches from the outside edge. Beginning at the bottom, the points for the rods should be located 26 inches apart on this line. Holes should be bored at each one of these points with a bit 1/16-inch larger than the size of the rods to be used. These 6-inch boards are then ripped apart upon this line.

The next step is to nail together the 8-inch board C and the wider part of the 6-inch board A. Five or six pieces of 6-inch board (E in the plate), should now be sawed and nailed to the underside of the 8-inch boards, care being taken that the two sides of the form are squared with each other before these boards are nailed into place. To insure a uniform distance between the posts when the form is completed a gauge 18 inches long should be prepared and used between the two halves of the form during this nailing. The 2x2's, which have been dressed out and sawed the proper length, may now be securely nailed in the corners of these two boxes, care being taken that the bevel is laid in the right direction. The rods, which should be of ¾-inch iron and 32 inches long, with a 2-inch right angle turned at each end, can now be placed in the holes, and the narrow strip which was ripped off can be cleated back into place. A cleat should be used at each rod and should be carefully nailed with 4-penny nails. The 2x4's (H in the plate), which have been spliced together to a length of exactly 30 feet, may now be placed in the form, to which they may be fastened by means of boards across the front. These 2x4's should be gauged out 7 inches from board A.



Detail of Door Frame.

The door form is now ready to be raised into place. When it has been raised to a vertical position, it should be lifted up high enough so that the 8-inch board can be let down on the inside of the metal lath already in place. The 2x4's should rest squarely on the foundation and against the lath on the outside. This form must now be carefully plumbed and held in place by short braces to the posts and planking of the scaffold. All braces must be nailed to the form on the inside so as not to interfere with the subsequent placing of the metal lath or other material.

The 2x4 studding should be prepared for raising by being spliced together to a length exactly of 30 feet, or the exact height of the silo above the foundation. The splice may be made by lapping the ends and nailing them together with three 16-penny nails.

The plate pieces, which have been sawed out in accordance with the figures given, should now be hoisted to the top of the platform of the scaffold. Light gauges should be prepared for use in space the 2x4's. It is a good plan to have the gauge used on the top platform notched at one end so that it may be used in placing the inner edge of the 2x4 2 inches out from the inner edge of the plate.

In raising the studding to place, begin operations by taking one of the plate pieces and nailing it across the top of the door form, which is already in place, the inside edge being placed 2 inches in from the edge of the 2x4's. A single 8-penny nail driven into the top of each 2x4 is sufficient to hold this in place. Now build out two or three sections of the plate, breaking joints and doubling, securely nailing together the two layers with 6-penny nails. In raising the 2x4's, a light line is a great convenience, one end of it being made fast to the top end of the 2x4's with a timber hitch, so that one of the men on top can pull the stick up, while the man below carries the foot toward the scaffold and sets it in the proper place on the foundation. This

2 x 4 should be spaced out the proper distance from the 2 x 4 of the door form, also out 2 inches from the inside edge of the plate; a 16-penny nail should be driven into it through the plate. Raise the next 2x4 in like manner, building the plate on ahead two or three sections at a time. As soon as three or four 2x4's are in place, a piece of light material, such as ordinary weather-boarding, should be bent to the form of a hoop and nailed to each 2x4, 4 or 5 feet above the foundation, with a 4-penny nail, spacing the studding with the same length of gauge as has been used at the top.

Raising the Door Form.

These strips of weather boarding should be extended as the 2x4's are set until circle is completed.

Since the door form is carefully plumbed before one begins to raise the 2x4's, little difficulty is experienced, as a rule, in having the whole structure stand perpendicular when the circle is complete. In order to have the segments of the plate unite properly, it will probably be necessary to loosen the braces, which were nailed on top before the circle was complete. After the parts of the plate have been brought together the braces should again be nailed in place, so that the scaffold and the studding may be securely tied together. A second hoop should be placed around the silo about halfway down from the top; and if the 2x4's are very crooked and badly out of line, it may be necessary to place still another hoop.

The pieces of gas-pipe, which have previously been cut to the right length, should now be placed in each door box and wired to the ends of the rods across the door form.

The 24-gauge expanded metal or metal lath is used in the construction of this silo. It comes in bundles, each bundle usually containing nine strips, 8 feet long and 18 inches wide. A bundle of this size contains 12 square yards and weighs 40½ pounds. This metal lath is tacked to the inside of the studding with double-pointed tacks. The work of placing it should begin at the top, starting at the door post. The end of the first strip should be passed through the opening in the side of the door box and bent around the gas-pipe already in place. Each strip of lath should be tacked first in the middle; the workman should go from that place toward the end, and should, as the tacks are driven, push out the lath so that it naturally takes the form of

Placing Door Frame Reinforcement

the circle. The end of the second piece should be lapped at least 3 inches on the piece already placed. So continue until the gas-pipe on the other side of the door is reached. A good pair of snips will be necessary in all this work, since there is considerable cutting of lath. Where the ends of lath pass the hooks of the rods across the door it will be necessary to split the end back about 4 inches, so that it can be bent around the gas-pipe properly. It is very important that the end passing around the gas-pipe be long enough to encircle it completely. Two workmen are needed to do this work to good advantage, and more men can be used if they are available. The different rounds of the lath should lap from ¼ to ½ inch, and in case any bagging is seen the edges must be wired together with light wire. This will prevent a great deal of annoyance to the plasterers in placing the first coat of plaster. Whenever it becomes necessary to splice the ends between studding, the splices must be carefully wired together. When the ends are spliced on the studding and lapped 3 inches, this wiring is not necessary. This expanded metal lath has a right and a wrong side, and the best results are secured if the material is so placed that the slant of the mesh is upward when looked at from the inside. If, when the bottom is reached, the lath does not come out even, which is usually the case, the last round may be left full width in case there is enough lath to allow this. Care taken in getting this lath smoothly placed and carefully wired will mean the saving of money later, since the plasterers can make better headway where this work has been properly done.

Although the first silos of this type contained no other reinforcement than the metal lath, it has since been thought desirable to place additional horizontal reinforcement in the form of strands of heavy wire completely encircling the silo. These wire strands cannot be placed until all of the inside plastering is done and the studding is removed. Provision must be made, however, for their attachment to the vertical reinforcement in the door post before any mortar is placed.

Means of attachment at the doors can be most easily provided for by fastening short wire loops to the gas-pipe in the door post. A 16-foot silo, 30 feet high, should have at least 150 pounds of additional wire reinforcement. Since the pressure is much greater at the bottom, gradually decreasing toward the top of the silo, a larger amount of the wire should be placed in the lower part of the wall. The table shows the correct spacing of the wires in a 16-foot silo below. The loops attached to the gas-pipe to which these wire strands are later to be fastened should be placed in accordance with this table, and may be put in place at the time at which the lath is being tacked to the studding, or just before the plastering begins.

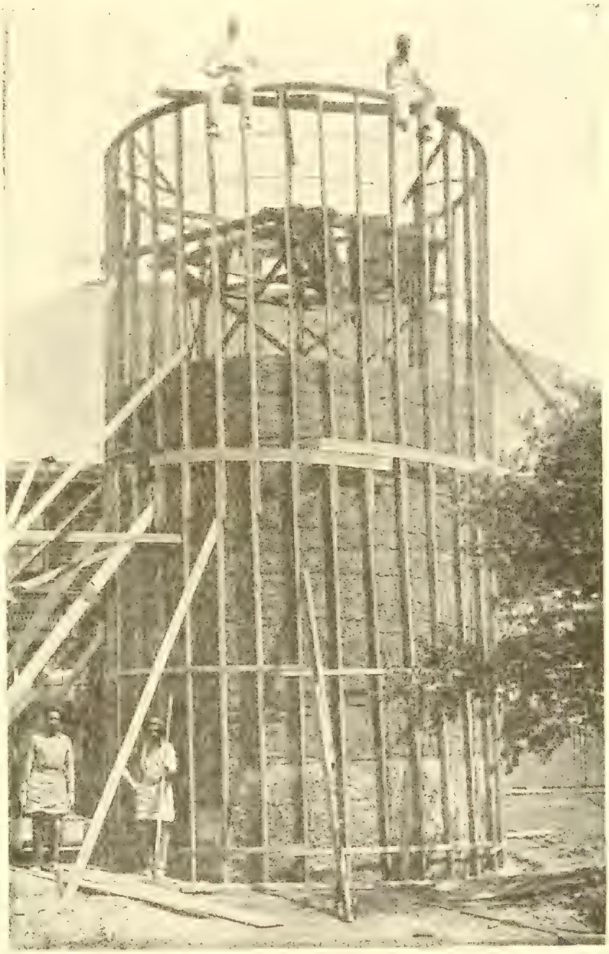
Table showing proper spacing of extra wire reinforcement for silo 16 feet in diameter.

Feet from top of silo	Number of strands of No. 9 wire required.
0- 4	1 strand for every 24 inches.
4- 8	1 strand for every 24 inches.
8-12	1 strand for every 24 inches.
12-16	1 strand for every 12 inches.
16-20	2 strands for every 12 inches.
20-24	2 strands for every 8½ inches.
24-28	2 strands for every 6½ inches.
28-32	2 strands for every 5 inches.
32-36	2 strands for every 4 inches.

Silos of larger size will require one additional strand of No. 9 wire for every 2 foot increase in diameter.

After the metal lath and the wire loops are in place, the thin boards, K, should be nailed in place, care being taken to press the edge as tightly as possible against the lath, since this box is to be later filled with mortar. Plenty of nails should be used to hold these boards, but the heads should be left slightly out so that they may easily be drawn later. If this precaution is not taken, some difficulty may be experienced in removing this board when the proper time comes.

Bolts are used to secure the plate to the finished wall of the silo, and these must be in place before the plastering begins. Then 3/8-inch bolts 10 inches long will be sufficient for silos not exceeding 16 feet in diameter. Holes should be bored in the plate and should be spaced at as nearly equal distances apart as possible. The bolts should be supplied with washers and should be passed through the plate from below, and the nuts put on. The bolts should hang down below the plate just inside the metal lath so as to be covered by the first coat of plaster.



Applying the First Coat of Plaster to the Inside.

It is almost necessary to have a chute on the silo, and provision should be made for attaching this chute by placing five or six bolts 3/8 inch by 4 inches in a perpendicular line 3 or 4 inches outside of the door post. These bolts may be passed through the metal lath with the nuts on the outside. As the plastering progresses, care should be taken that the bolts are made to project perpendicularly from the wall.

The mixture for the scratch coat consists of 1 part of cement, 2½ parts of sand, and 10 per cent as much hydrated lime as cement. About 1 bushel of hair to every 300 square feet of surface to be covered must be used in this first coat. For the plastering of a silo 16 by 30 feet, about 7 sacks of hydrated lime and 5 bushels of hair will be required. The lime should be soaked up 10 or 12 hours before it is to be used. The hair should be thoroughly beaten part on a barn floor, and after being soaked several hours should be carefully picked to pieces and worked into the lime putty which has been prepared. If care is used, the hair will be thoroughly mixed with the lime and the mixture can be added to each batch of the cement mortar as it is being prepared for use. It will take about 1½ pailfuls to each 2 bag batch of mortar. It will be well for the plasterer to make some estimate as to the right amount of this to use in each batch, so as to have enough to use for the whole scratch-coat. This coat will require about 13 two-bag batches of mortar for 16x30 foot silo.

Two good plasterers will be required, and four tenders, two to measure materials and mix the mortar, one to carry and elevate it to the proper platform, and the fourth to receive the mortar on the platform and place it on the mortar-boards. This last man should do all the moving and shifting work, so that the plasterers may not be delayed at any time.

Sometime during the process of applying the scratch coat, the space under the door should have been cased up inside and out and filled with mortar mixed in the proportion of 1 part of cement to 2½ parts of sand. A strip of wood should be placed across the bottom so that the shoulder which is cast at the side of the doors will be continued across the bottom of the door.

When the scratch coat is all on, the door posts are to be filled. Since the 8-inch boards forming the inside of the form have a tendency to spring back under the weight of the mortar, some provision must be made to hold these boards rigidly in place. This can easily be accomplished by firmly nailing short braces to the scaffold plank at each platform, the ends being braced solidly against the back of the form.

If this work can be completed by quitting time at night, or even by working overtime, the thin boards on the inside can be removed the next morning. Considerable care must be used in removing these boards, since the mortar will be rather green and easily injured. The placing of the remaining layers of plaster can now proceed with no further delay.

The mixture for the second layer of plaster should consist of 1 part of cement to 2½ parts of sand, and should be applied in three coats, giving a total thickness, including the scratch-coat of at least 1¾ inches. In applying these coats, begin at the top and work down, one coat following the other as rapidly as possible. An old broom should be kept on the scaffold, and the helper should rough up each coat as soon as it has wet sufficiently, so that succeeding coats will not be applied to the glossy surface left by the trowel. It is necessary at all times to keep water upon the scaffold, since many times the work will dry too rapidly and it will become necessary to sprinkle the wall before the next coat of plaster is applied.

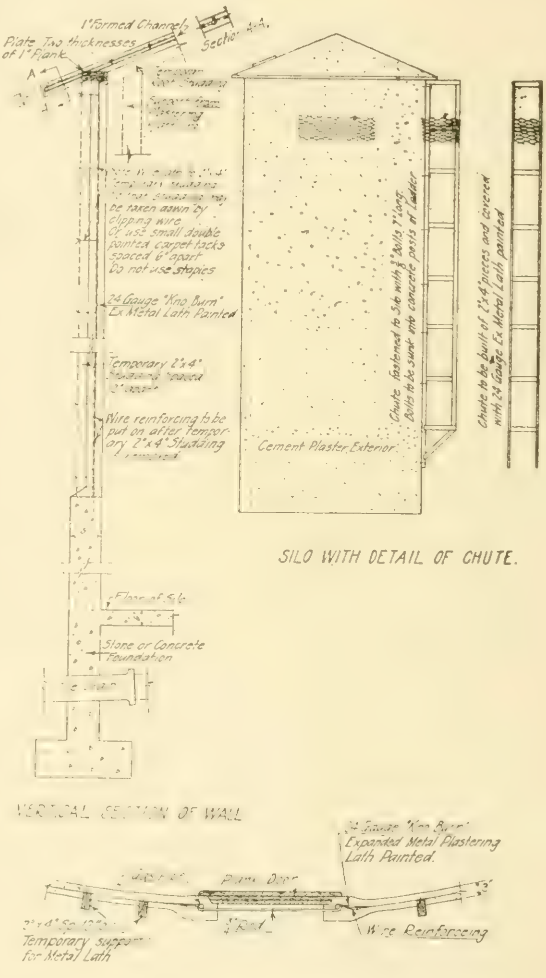
Before applying the last layer of plaster to the inside, the inner part of the door form should be removed. With this form out of the way, the finish coat, consisting of equal parts of cement and screened sand, may be smoothly applied in such a manner as to leave the inside surface flush with the face of the door post. The use of water is very important during the application of this coat. A force pump, preferably a pump run by a gasoline engine and a line of hose, is a great convenience in keeping the walls thoroughly wet.

The finish coat should be smoothed up neatly. When it has sufficiently set, one of the plasterers should mix up a wash of pure cement and give it what is commonly called a "slush coat." It should be the aim of the plasterer to finish this coat and have it set without the appearance of checks of any kind. This coat should extend down upon the foundation wall to the bottom of the silo.

Under ordinary conditions, by the time the inside is finished, the wall, which is now 2 inches thick, has set sufficiently to permit the removal the outside studding and parts of the door form still in place. The inside scaffold should be removed also; one should begin at the top and pass the material out through the door opening. The first step in taking down the temporary studding is to remove all the hooping material. When the foot is forced loose, the 2x4 may be pulled out straight from the silo until it is free except for the nail at the top. By pulling down on the stick, one may detach it from this nail and lay it on the ground. It is a good plan to determine the number of legs necessary for the outside scaffold before removing these studs. By leaving two of them at each point where the scaffold legs are to stand, they can later be loosened from the wall and stood out at the proper places, thus saving the labor of raising them from the ground again while building the outside staging.

Pouring the Door Posts.

Before the plastering on the outside is begun the extra wire reinforcement should be put in place. This wire is to be attached to the wire loops which now lie flat on the outside of the wall. The number of strands of wire to be placed at each loop is given in the table. These hoops of wire should be passed around the silo and attached to the loops on the opposite side. Continue this process until all hoops have bands of wires attached to them.



SILO WITH DETAIL OF CHUTE.

VERTICAL SECTION OF WALL

HORIZONTAL SECTION OF WALL AT DOOR.

The lumber used for the inside scaffold is to be used in building a scaffold on the outside, the 30-foot 2x4's left in place being used for the legs of the scaffold. Care must be taken that the inside legs and the plank runway of this scaffold are at such a distance from the wall of the silo as will be convenient for the plasterers to work.

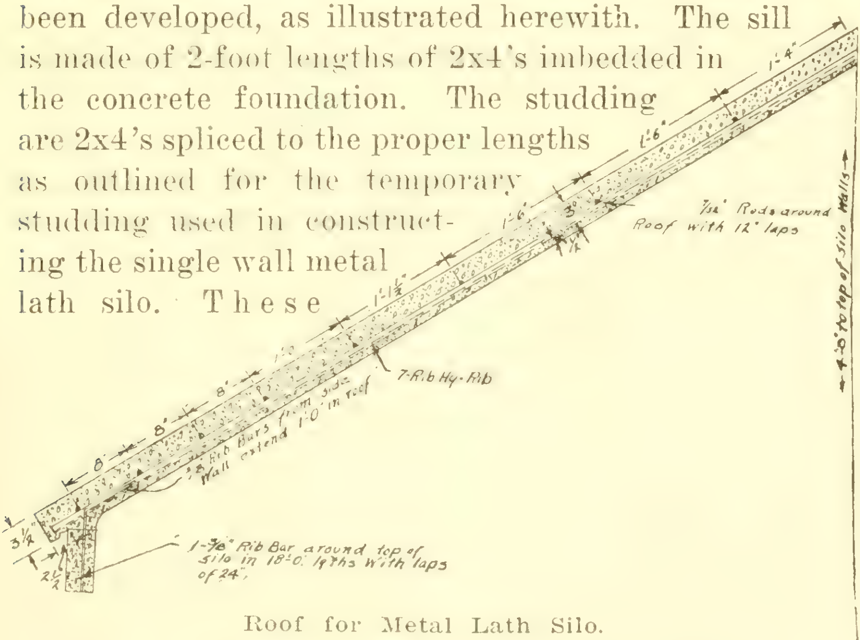
The outside layer of plaster should be at least 1 inch in thickness and should be applied in 2 coats, using one part of cement to 2½ parts of sand. The use of the darby on the last outside coat will add to the appearance of the silo. A float finish gives a pleasing appearance to the outside.

The use of a wash coat of pure cement as a final finish will also greatly improve looks of the silo. The walls should be thoroughly wet before this coat is applied.

The finished silo should be wet thoroughly once daily for at least a week after the job is complete. The use of water is a very important factor in the securing of a good concrete job built above ground, since the constant tendency is for the material to dry before proper setting can take place.

The same type of doors described for use in the solid-wall silo with continuous door opening can be used in this silo.

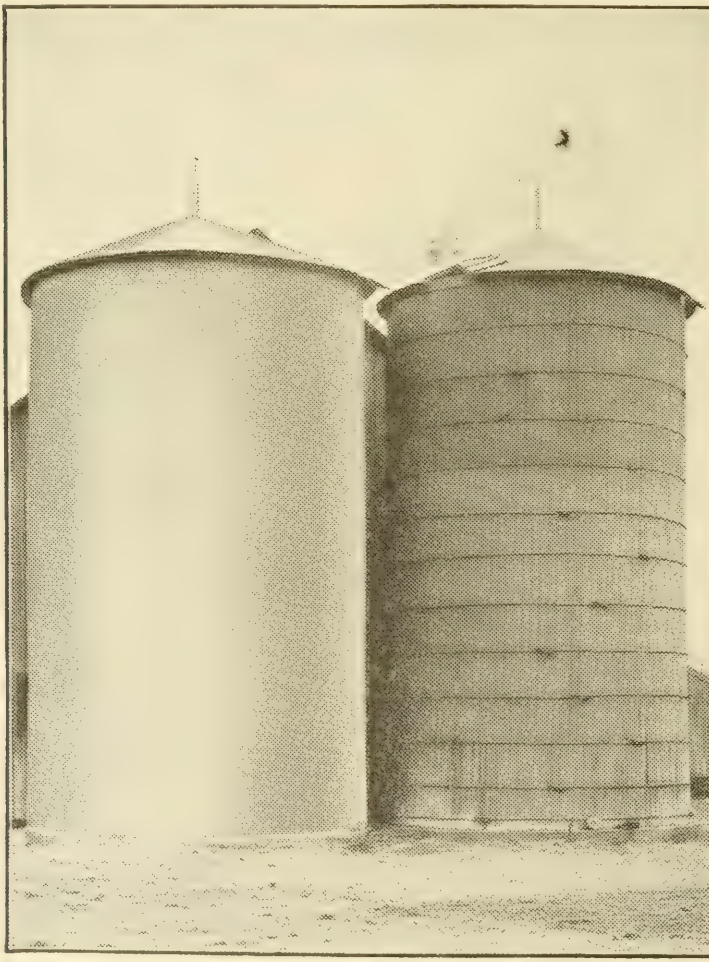
In order to provide against freezing of silage in severely cold climates, a double-wall metal-lath silo has been developed, as illustrated herewith. The sill is made of 2-foot lengths of 2x4's imbedded in the concrete foundation. The studding are 2x4's spliced to the proper lengths as outlined for the temporary studding used in constructing the single wall metal lath silo. These



Roof for Metal Lath Silo.

studding are set on the sill and are toe-nailed to it. On each side of the door opening are set two 2x4's spiked together to form 4x4's for the door frame.

These are bolted together across the opening by ¾ inch rods. A jamb for the doors to fit against is formed by sawing a 2x4 as outlined previously in this chapter. The plate at the top of the silo is made the same as for a single wall silo. After the frame has been completed metal lath is stapled to both the inside and outside of



Concrete Silo for Walker Bros., Walkerville, Ont.

Note the attractive appearance of permanent Concrete Silo (at left) compared with wood silo (at right) which is already showing signs of deterioration.

TABLE VIII.—SHOWING AMOUNT OF LATH AND WIRE REQUIRED FOR SINGLE-WALL METAL LATH SILOS.

Compiled By Northwestern Expanded Metal Co.

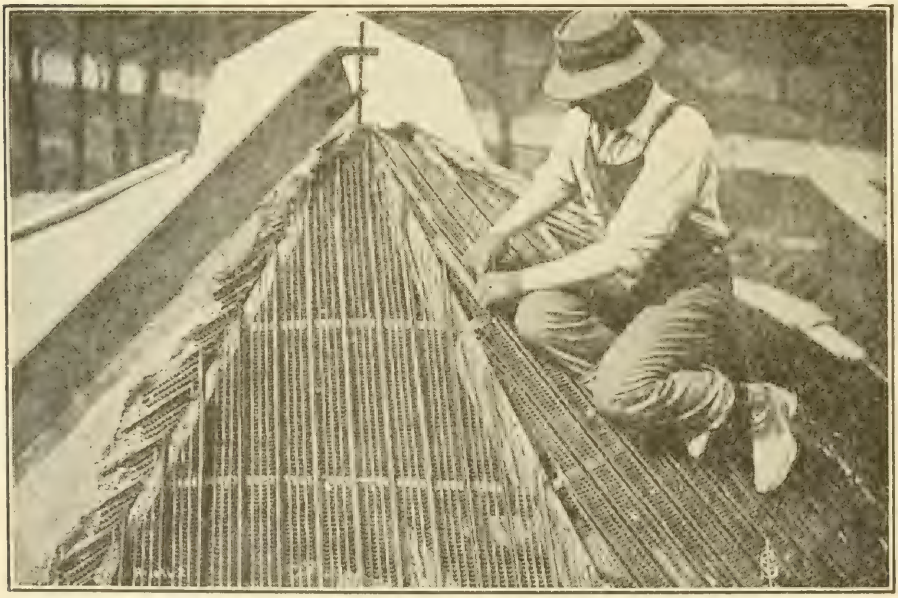
Diameter of Silo in Feet	Height of Silo in Feet								
	20	22	24	26	28	30	32	34	36
10	72 Sq. Yds. of Lath No Wire reinforcement required	84 Sq. Yds. of Lath No Wire reinforcement required	90 Sq. Yds. of Lath No Wire reinforcement required	96 Sq. Yds. of Lath No Wire reinforcement required	102 Sq. Yds. of Lath No Wire reinforcement required	108 Sq. Yds. of Lath No Wire reinforce ment required	120 Sq. Yds. of Lath No Wire reinforcement required	126 Sq. Yds. of Lath 66 Lin. Ft. No. 12 Wire	132 Sq. Yds. of Lath 132 Lin. Ft. No. 12 Wire
12	90 Sq. Yds. of Lath No Wire reinforcement required	96 Sq. Yds. of Lath No Wire reinforcement required	108 Sq. Yds. of Lath No Wire reinforcement required	114 Sq. Yds. of Lath No Wire reinforcement required	120 Sq. Yds. of Lath No Wire reinforcement required	132 Sq. Yds. of Lath No Wire reinforce ment required	138 Sq. Yds. of Lath 158 Lin. Ft. No. 8 Wire	150 Sq. Yds. of Lath 198 Lin. Ft. No. 8 Wire	156 Sq. Yds. of Lath 276 Lin. Ft. No. 8 Wire
14	102 Sq. Yds. of Lath No Wire reinforcement required	114 Sq. Yds. of Lath No Wire reinforcement required	120 Sq. Yds. of Lath 46 Lin. Ft. No. 8 Wire	132 Sq. Yds. of Lath 92 Lin. Ft. No. 8 Wire	144 Sq. Yds. of Lath 184 Lin. Ft. No. 8 Wire	150 Sq. Yds. of Lath 322 Lin. Ft. No. 8 Wire	162 Sq. Yds. of Lath 414 Lin. Ft. No. 8 Wire	174 Sq. Yds. of Lath 598 Lin. Ft. No. 8 Wire	180 Sq. Yds. of Lath 782 Lin. Ft. No. 8 Wire
16	120 Sq. Yds. of Lath No Wire reinforcement required	126 Sq. Yds. of Lath 52 Lin. Ft. No. 8 Wire	138 Sq. Yds. of Lath 156 Lin. Ft. No. 8 Wire	150 Sq. Yds. of Lath 260 Lin. Ft. No. 8 Wire	162 Sq. Yds. of Lath 364 Lin. Ft. No. 8 Wire	174 Sq. Yds. of Lath 520 Lin. Ft. No. 8 Wire	186 Sq. Yds. of Lath 728 Lin. Ft. No. 8 Wire	198 Sq. Yds. of Lath 1040 Lin. Ft. No. 8 Wire	210 Sq. Yds. of Lath 1350 Lin. Ft. No. 8 Wire
18	132 Sq. Yds. of Lath 176 Lin. Ft. No. 8 Wire	144 Sq. Yds. of Lath 293 Lin. Ft. No. 8 Wire	156 Sq. Yds. of Lath 410 Lin. Ft. No. 8 Wire	168 Sq. Yds. of Lath 585 Lin. Ft. No. 8 Wire	180 Sq. Yds. of Lath 877 Lin. Ft. No. 8 Wire	192 Sq. Yds. of Lath 1230 Lin. Ft. No. 8 Wire	204 Sq. Yds. of Lath 1580 Lin. Ft. No. 8 Wire	222 Sq. Yds. of Lath 2050 Lin. Ft. No. 8 Wire	228 Sq. Yds. of Lath 2510 Lin. Ft. No. 8 Wire
20	144 Sq. Yds. of Lath 325 Lin. Ft. No. 8 Wire	162 Sq. Yds. of Lath 520 Lin. Ft. No. 8 Wire	174 Sq. Yds. of Lath 780 Lin. Ft. No. 8 Wire	186 Sq. Yds. of Lath 1170 Lin. Ft. No. 8 Wire	198 Sq. Yds. of Lath 1560 Lin. Ft. No. 8 Wire	216 Sq. Yds. of Lath 1950 Lin. Ft. No. 8 Wire	228 Sq. Yds. of Lath 2470 Lin. Ft. No. 8 Wire	246 Sq. Yds. of Lath 2990 Lin. Ft. No. 8 Wire	258 Sq. Yds. of Lath 3580 Lin. Ft. No. 8 Wire
22	162 Sq. Yds. of Lath 573 Lin. Ft. No. 8 Wire	180 Sq. Yds. of Lath 857 Lin. Ft. No. 8 Wire	182 Sq. Yds. of Lath 1215 Lin. Ft. No. 8 Wire	204 Sq. Yds. of Lath 1645 Lin. Ft. No. 8 Wire	222 Sq. Yds. of Lath 2142 Lin. Ft. No. 8 Wire	228 Sq. Yds. of Lath 2720 Lin. Ft. No. 8 Wire	252 Sq. Yds. of Lath 3360 Lin. Ft. No. 8 Wire	270 Sq. Yds. of Lath 4220 Lin. Ft. No 8 Wire	288 Sq. Yds. of Lath 5075 Lin. Ft. No. 8 Wire
24	174 Sq. Yds. of Lath 936 Lin. Ft. No. 8 Wire	182 Sq. Yds. of Lath 1405 Lin. Ft. No. 8 Wire	210 Sq. Yds. of Lath 1870 Lin. Ft. No. 8 Wire	222 Sq. Yds. of Lath 2500 Lin. Ft. No. 8 Wire	240 Sq. Yds. of Lath 3120 Lin. Ft. No. 8 Wire	258 Sq. Yds. of Lath 3744 Lin. Ft. No. 8 Wire	276 Sq. Yds. of Lath 3258 Lin. Ft. No 8 Wire	306 Sq. Yds. of Lath 5776 Lin. Ft. No 8 Wire	332 Sq. Yds. of Lath 6708 Lin. Ft. No. 8 Wire
26	186 Sq. Yds. of Lath 1351 Lin. Ft. No. 8 Wire	204 Sq. Yds. of Lath 1945 Lin. Ft. No. 8 Wire	222 Sq. Yds. of Lath 2620 Lin. Ft. No. 8 Wire	246 Sq. Yds. of Lath 3380 Lin. Ft. No. 8 Wire	264 Sq. Yds. of Lath 4400 Lin. Ft. No. 8 Wire	282 Sq. Yds. of Lath 5410 Lin. Ft. No. 8 Wire	300 Sq. Yds. of Lath 6850 Lin. Ft. No. 8 Wire	338 Sq. Yds. of Lath 7950 Lin. Ft. No. 8 Wire	336 Sq. Yds. of Lath 9460 Lin. Ft. No. 8 Wire
28	204 Sq. Yds. of Lath 910 Lin. Ft. ¼ inch Rods	222 Sq. Yds. of Lath 1275 Lin. Ft. ¼ inch Rods	240 Sq. Yds. of Lath 1640 Lin. Ft. ¼ inch Rods	264 Sq. Yds. of Lath 2090 Lin. Ft. ¼ inch Rods	282 Sq. Yds. of Lath 2640 Lin. Ft. ¼ inch Rods	300 Sq. Yds. of Lath 3280 Lin. Ft. ¼ inch Rods	324 Sq. Yds. of Lath 4000 Lin. Ft. ¼ inch Rods	312 Sq. Yds. of Lath 4725 Lin. Ft. ¼ inch Rods	360 Sq. Yds. of Lath 5375 Lin. Ft. ¼ inch Rods
30	228 Sq. Yds. of Lath 1165 Lin. Ft. ¼ inch Rods	240 Sq. Yds. of Lath 1555 Lin. Ft. ¼ inch Rods	258 Sq. Yds. of Lath 2040 Lin. Ft. ¼ inch Rods	282 Sq. Yds. of Lath 2620 Lin. Ft. ¼ inch Rods	300 Sq. Yds. of Lath 3400 Lin. Ft. ¼ inch Rods	324 Sq. Yds. of Lath 4175 Lin. Ft. ¼ inch Rods	336 Sq. Yds. of Lath 5050 Lin. Ft. ¼ inch Rods	306 Sq. Yds. of Lath 6215 Lin. Ft. ¼ inch Rods	384 Sq. Yds. of Lath 7275 Lin. Ft. ¼ inch Rods

the studding, placed with the long dimension around the silo.

In estimating the quantity of metal lath required for a double wall silo, the table given in this chapter can be used, remembering to use just twice the amounts.

Silos are also made from the various special patented types of metal lath now on the market. With some of these it is found to be possible to erect the silo without the use of the temporary studding previously described.

One such is the product known as Hy-Rib, made by the Trussed Concrete Steel Company, Youngstown, O. This is a herringbone metal lath with deep corrugations or ribs pressed in it at regular intervals, these giving



Hy-Rib Acts As a Form and Reinforcement for the Concrete.
Note the temporary wood frame for metal sheets. If the wood frame-work is to be removed the sheets must be wired together. If 2x4-inch rafters are to be left the metal may be nailed lightly to them and the cross boards only removed. This is undoubtedly the quickest and cheapest method.

it strength and stability. The type usually recommended for silos is made from 24 gauge metal, has the ribs 4 inches apart and 15/16 inch high, and comes in sheets 24 inches wide and 10 and 12 feet long. For silo work these sheets are curved at the mill to the desired radius. These sheets can either extend down into the foundation, as shown in the illustration, or can begin at the top of the foundation. In the latter case dowel pins are set in the foundation, and allowed to extend several inches above it, for attaching the first ring of Hy-Rib. The construction as shown in the illustration is recommended, however, carrying the metal down to the footings.

It will be noted also that rib bars are used to give stability to the walls while being plastered. These are 3/8 inch ribs, wired to the metal sheets, and left in as a permanent part of the silo. Plaster is applied on both sides of the metal to a total thickness of 3 or 3½ inches.

In this type of construction the builder may erect the metal to a height of 30 feet before beginning to plaster, or he may erect it in sections and plaster, as desired. After any plastering is done, however, it will require at least a half day to harden before any more metal is placed.

The roof of a Hy-Rib concrete silo may be of a cone shape, a dome shape, or an octagonal hip, which are all constructed of Hy-Rib covered with 2 inches of concrete, back-plastered underneath. The chute may be built in connection with the side walls using Hy-Rib of any desired size, thereby making the chute, side walls and roof of silo one complete unit with the foundation.

A silo similar to the above is made by the use of Trusridge expanded metal, made by the Edwards Metal Structures Company, Kansas City, Mo. In this case, however, $\frac{1}{2}$-inch pipe is used for studs, to which the metal is wired. The pipes are furnished in 10 and 12-foot lengths, threaded for unions, and are held in place by a ring of angle iron which has holes punched in it for the pipes. This ring holds the pipes to a true circle.

CHAPTER XV

The Concrete Stave Silo

The concrete stave silo is patterned after the wood stave silo, and has been developed in an attempt to introduce some of the elements of ease of erection and low cost of the wood silo, combining with them the features so desirable in concrete.

These silos are built up of members resembling staves, and erected and held together in the same manner. It would manifestly be impossible, however, to make them in such lengths as are handled in wood, so that the length of the concrete staves is limited usually to 28 or 30 inches. They may be either made on the job, or shop-cast and moved to the place of erection. In this latter case they can usually be cured under better conditions and there will not be the danger of hurrying them into the structure before the proper curing has taken place. These staves are usually poured of slush concrete in multiple steel molds.

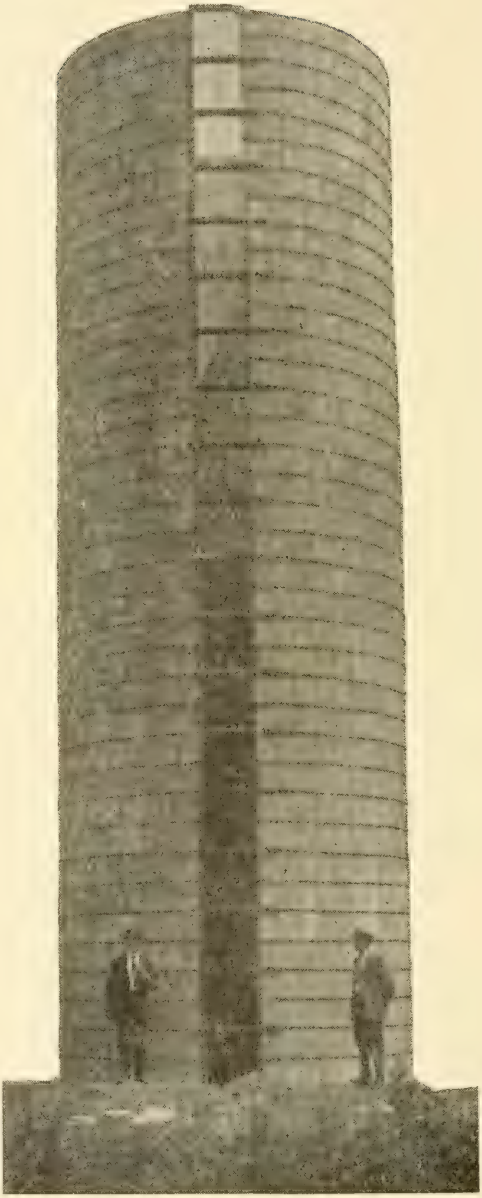
The staves are generally made in a width of about 10 inches and are cast flat. The usual thickness is about 2½ inches. All types have some method of giving the staves a vertical joint, and some of them also provide a horizontal joint where the ends of the staves come together. The joints are filled with mortar. To still further safeguard the structure against air and moisture, the inside may be plastered or given a wash coat of cement.

In constructing the silo the staves are assembled with staggered joints, the first row of staves consisting of alternate full length and half length staves.

These silos are held together by outside hoops, as is the case with wood staves, the hoops being placed closer together at the bottom to provide for the greater strain, the spacing being gradually increased as the top is approached.

Some of the commercial stave silo systems now on the market are described in the following pages.

Many of these silos have been built on the foundations of old wood stave silos and are giving excellent satisfaction, a point which is worth while remembering in promoting the sale of these silos. The foundation for the stave silo is made the same as for other types.

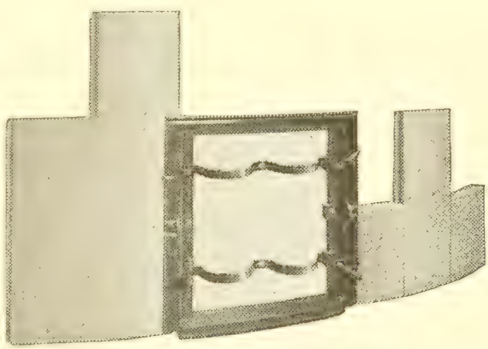


Perfection Stave Silo on State Fair Grounds at Des Moines, Ia. Diameter 14 feet 4 inches; height 44 feet 4 inches; capacity 194 tons.

Perfection Concrete Stave Silo. This system is controlled by the Perfection Concrete Stave Silo Company, Des Moines, Iowa, and the outfit with which the staves are made is sold outright to manufacturers. These staves can be used for structures from 10 to 36 feet in diameter and up to 60 feet high.

The staves are 28 inches long, 10 inches wide, 2¾ inches in thickness, and are made in steel forms with a wet mix, waterproofed and made impervious by the addition of 10 per cent of the weight of cement in hydrated lime. The staves are made concave on the edges and on the ends, and when they are assembled in the silo the space which is thus formed is filled with mortar.

The company also manufactures for use on its silos a malleable iron door frame and an all-steel door with steel ladder combination. The door system is continuous from the foundation to roof, the frame occupying a space of only 4 inches between doors. Each door opening is 23x25 in.



The Perfection Silo Steel Door in place; and showing steel ladder system on each door.

In constructing the silo, one of the malleable iron door frames is placed upon a circular concrete foundation, and half staves (that is, 14 inches in length by 10 inches in width by 2¾ inches in thickness), are placed on the foundation, in the channel on either side of the malleable iron door frame; then a full length stave is stood up by the side of each half stave, and the circle is completed by alternate half and whole staves. Thereafter, whole staves are used until the top of the silo is reached, when half staves are used to fill out the top, alternately between the full staves.

On completion of the first circle, two bands are placed around the circle, one 2 inches above the foundation and another half band is placed 14 inches above the foundation, and the end of the half band is placed in the lugs on either side of the door and turned up even with the end of the rod.

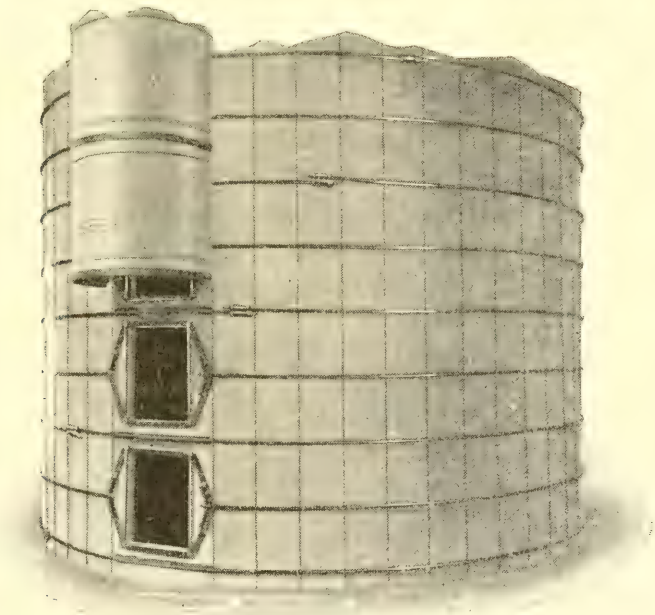
As each course is erected and put into place, the concavity between staves is filled with mortar, consisting of 1 part cement, to 3 parts of screened sand, and the ends of the staves as they meet are also filled with mortar, so that when the silo is completed every joint is filled, thus preventing any escape of the silage juices or admission of air into the silo.

Suitable collapsible staging is erected on the inside of the silo as the walls are being extended upward.

As soon as the silo walls are completed, a waterproofing composition is placed upon the inside wall by brush applications.

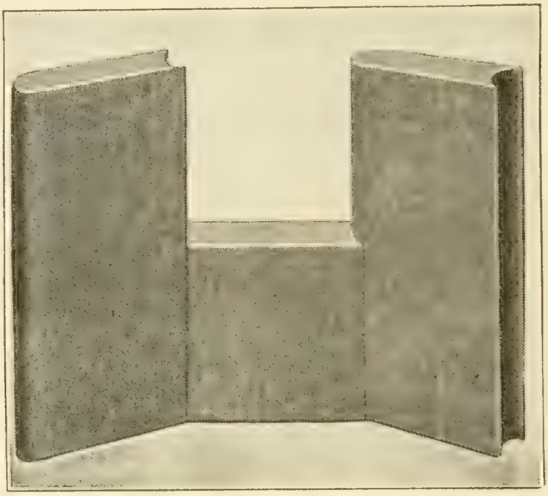
In this system the contractor is supplied with steel molds sufficient to cast 200 staves or more a day. The supposition is that the contractor will haul his molds to the farm, or the place where the silo is to be built, and that the owner will provide the materials ready for working. The contractor will then send two experienced men to cast the staves. The manufacturers state that it will require 900 staves to build a silo 16 feet in diameter by 35 feet high, holding 150 tons of silage. The two men it is stated will cast these in 4½ days. They are then left 4 or 5 days to cure before being erected.

Playford Cement Stave Silo. This system is controlled by the Cement Stave Silo Company, Des Moines, Iowa. These staves are made 30 inches long, 10 inches wide and 2½ inches thick. One edge is concave and the other convex, so that the staves fit closely together, no matter what the radius of the silo and the consequent curvature of the walls. In building a Playford Silo the first row consists of alternate full and half length staves; thus the joints are broken the entire way up, and the last row finished with alternate full and half lengths. These silos when erected are held together with hoops of round steel joined with patent lugs. These hoops are put on as the silo



Playford Silo With Door Spreaders and Chute.

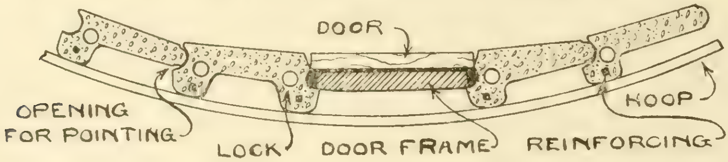
goes up, so that the structure is held perfectly rigid at every stage of construction. Alternate hoops entirely encircle the silo, when the intermediate hoops fasten to door spreaders, these passing around the



The Playford Cement Stave

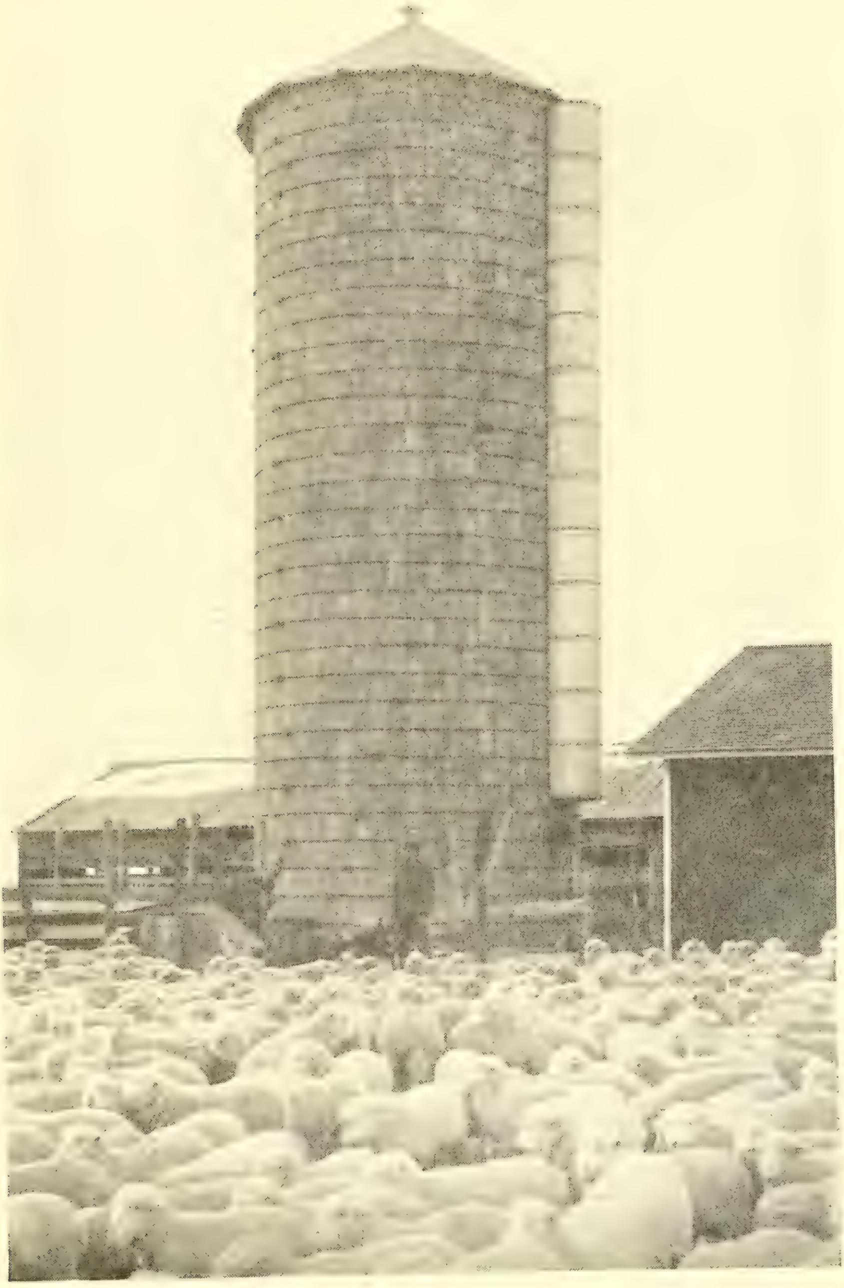
door openings and leaving them unobstructed. A combination sectional ladder and chute is also provided. After erection the silo is treated with a special waterproof filler coating on the inside.

Reinforced Stave Silo. This stave, which is controlled by the Playford Manufacturing Company of



Reinforced Stave Silo

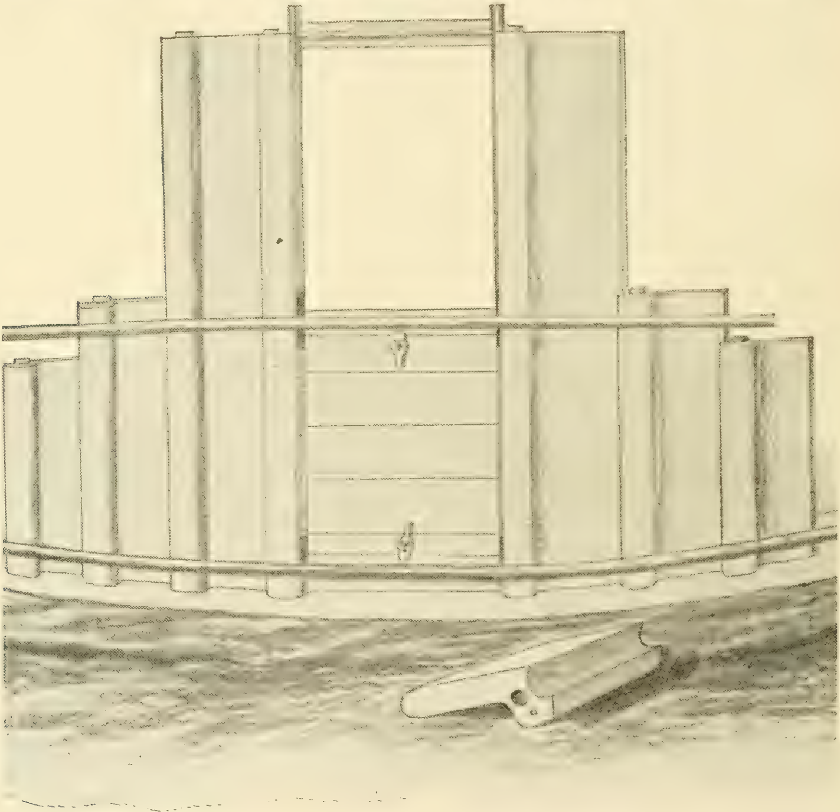
Elgin, Illinois, carries an outside vertical rib on one edge through which passes a ¼-inch twisted reinforcing bar. The thickness through the stave proper is



Playford Cement Stave Silo.

2¼ inches while the thickness through the rib is 4½ inches. The stave is 12 inches wide and 30 inches long.

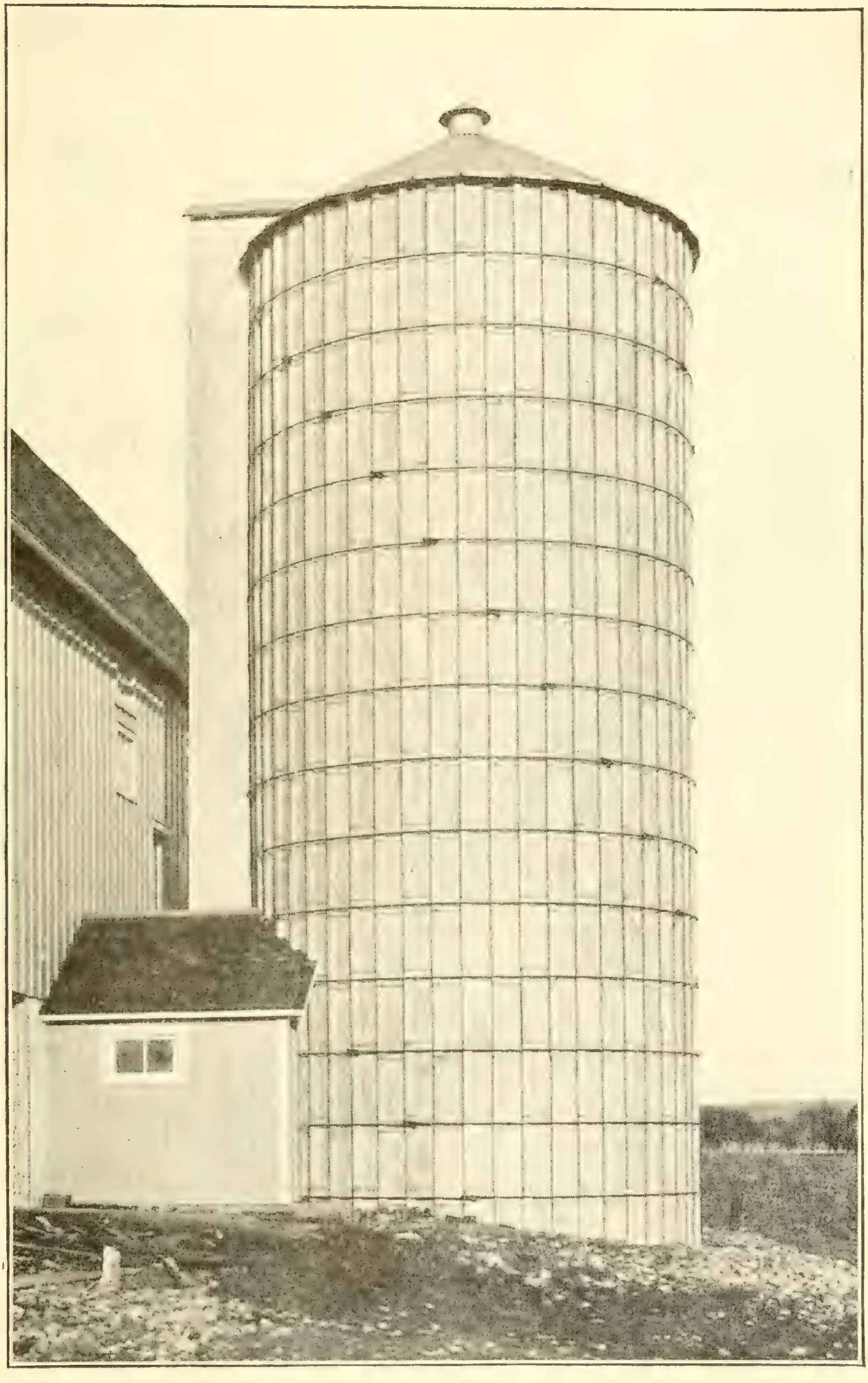
Each stave carries a lug on top with a corresponding recess in the bottom, forming a lock for the lateral joints. A concave and convex joint on the sides of



Method of Assembling Reinforced Silo Staves

the slabs is so designed that space is allowed for pointing up on the outside after the silo is erected. The silo is also given a cement wash on the inside, giving it a double seal.

The ribs on the outside of the staves carry properly spaced depressions for receiving the hoops, so



Reinforced Stave Silo

that the latter cannot slip out of place. The hoops, being held out from the face of the silo by the ribs, form a convenient ladder for climbing up the silo at any point.

A continuous door system is provided for, special staves being made for the door opening which carry an offset against which the door can rest and also having recesses into which a casting can be slipped as a dividing plate between doors. This casting is held firmly in place automatically when both the upper and lower staves are in position. The doors are of wood, held in place by latches which are turned over the flange of the castings above and below.

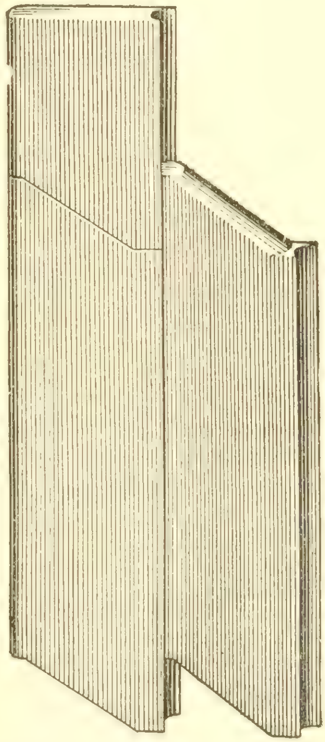
A galvanized iron roof is usually put on, with a chute either of that material or built up of the staves themselves.

The staves are poured of a slush mixture in individual molds of sheet steel and are allowed to remain in the molds for 24 hours.

Interlocking Cement Stave Silo. This system, controlled by the Interlocking Cement Stave Silo Company, Des Moines, Iowa, has as its most noticeable feature a bevel on the ends of each stave. This irregular form of joint makes it possible for a single band passing around the joint to hold the ends of all staves —both those above and those below. Concave and convex edges also provide an additional interlock.

The staves are 28 inches long, 10 inches wide and 2½ inches thick. The company makes two types of equipment for the manufacturing of these staves, one of them adapted to the manufacture of small and intermittent lots of staves, and the other a larger outfit for making larger quantities. Both make identically the same design of product.

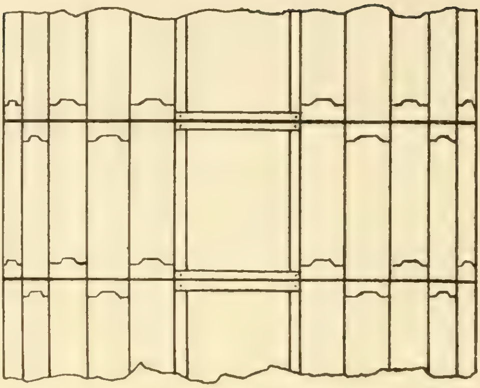
The first mentioned is a hand mold, open at top and bottom and designed to rest on a pallet and be withdrawn after the concrete is tamped in and struck off; the other is a machine somewhat similar to a concrete block or brick machine, in which the operations are done more rapidly by mechanical means. Both outfits are provided with means for making fractional staves as needed.



Interlocking Cement Staves.

A mold for casting a sectional concrete door frame is also a part of each outfit. This door frame is the same height as a stave, 28 inches, and 40 inches wide, taking the place of four staves; it also is provided with one concave and one convex edge to fit into adjoining staves. It thus can be used continuously or intermittently as desired. The door frame has an opening of 28x20 inches, with an offset to accommodate a wood door.

Swan Stave System. This design of stave was originated by the Swan Concrete Stave Silo Company, Cassopolis, Michigan. It is a dry tamp stave made in a simple form on wood pallets, the pallets being curved to the radius of the silo. The staves are dovetailed on the ends and each stave also has a tongue on one side and top and a groove on the other side and the



Swan Stave Silo

bottom. The staves are 30 inches long, $10\frac{5}{8}$ inches wide, and $2\frac{1}{2}$ inches thick.

Supreme Silo. The patent on this silo is held by J. A. Broderick, of Marshalltown, Iowa. It is built with either a single or double wall, the former being recommended for warmer climates and the latter for colder. The distinctive fea-

A Plant Manufacturing Swan Staves

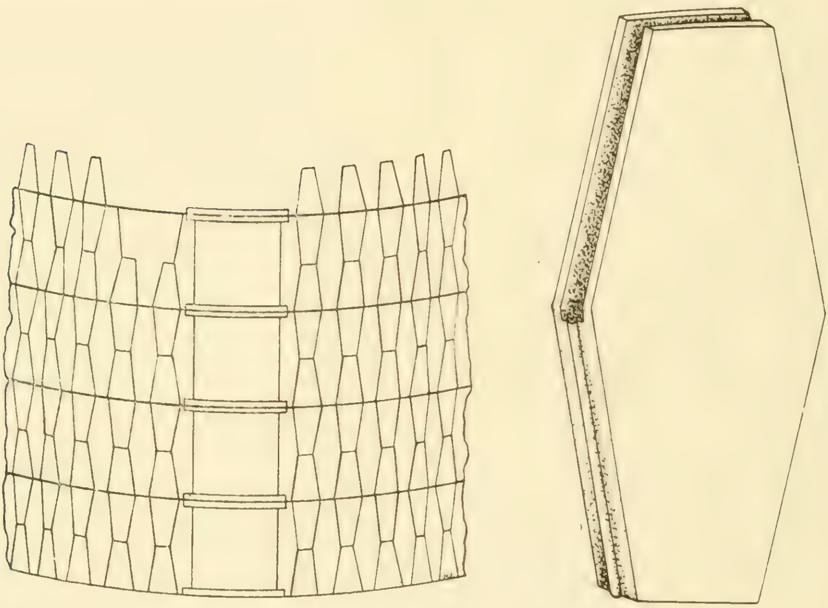
ture of this system is a concrete band or rib which is cast around the silo after the slabs are laid up, one of these being placed at each joint and serving to cover the reinforcing as well as cover the joint between the ends of the slabs. In order to accomplish this result the slabs are laid up with even lateral joints and staggered vertical joints, just the opposite of the general custom in stave construction. The concrete ribs, being carried completely around the structure, also form sills and lintels for the door frames where they cross the door openings.

Everlasting Silo Staves. W. W. Rohrer & Son of Orrville, Ohio, have a system of silo stave manufacture to make staves 24 inches long, 10 inches wide and 3 inches thick. One vertical edge of each stave is concave and the other convex, making a perfect joint. Half length staves are used in starting the silo, so that joints are broken all the way up. The staves are held together with ⅝-inch iron rods with patent knuckles. As each row of staves is placed in position the hoop is placed around and drawn up tight, each band passing around the middle of half the staves and the ends of the intermediate ones.

It is claimed that a special mixture is used in making these staves, rendering them impervious to moisture and also acid proof.

Panel Silos. These can perhaps best be included under the general heading of stave silos, although in this case the units run horizontally instead of vertically. This system is controlled by the Concrete Panel Silo Company of Kansas City, Missouri. It consists of poured concrete columns alternating with precast concrete slabs. The slabs are 10 inches high, 24 inches long, and 3 inches thick.

In erecting the silo, the slabs are first laid up to a convenient height, with reinforcing rods in the horizontal mortar joints between courses. The ends of the slabs have an outside bevel, leaving a considerable outside opening between the ends. Against this opening a steel form is erected and poured full of concrete, thus closing up the joint, and making a column to add to the stability of the structure. This column is reinforced with a 3/8-inch vertical rod. Intermittent



Diamond Stave Silo

door openings are made by omitting three panels at suitable intervals in one tier.

Diamond Concrete Stave Silo. This system is sold by the Diamond Concrete Stave Silo Company, Kansas City, Mo. These staves are diamond shaped, interlocking with tongue and groove, and held together by either round rods or bands. They are 30 inches long, 11½ inches wide at the middle and 6 inches at the ends. A notable feature of the staves is that they are thicker in the center than at the edges, the center thickness being 3 inches and at the edges 2¾ inches. This provision is made to give the finished silo an outside curvature, allowing the bands to fit more snugly instead of resting only on the edges of the staves.

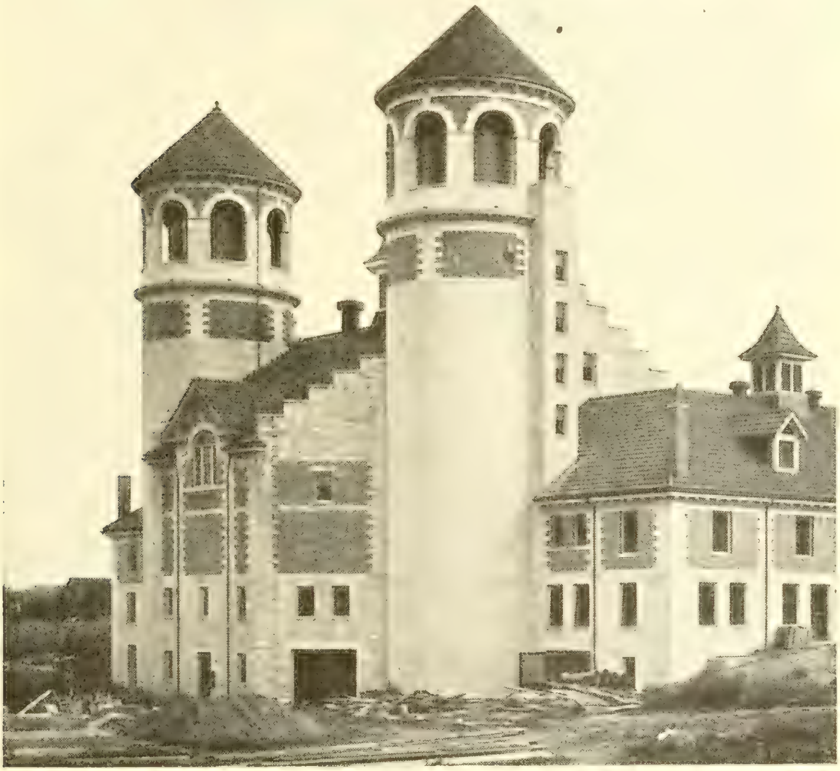
CHAPTER XVI

Concrete Block Silos

The concrete block silo, if well made, has at least two advantages to recommend it: It is usually made of hollow blocks, thus providing an air space in the wall which will help to insulate the contents against frost and moisture; and if some care is taken in the design and construction, it can be given a more decorative appearance than is customary with the general run of farm structures.

On the other hand there are certain precautions which must be taken in putting up this kind of a silo. Most of the silo block systems provide for a dry or semi-dry tamp block. With such a block it is of the utmost importance that the materials be properly selected, graded and mixed, and the manufacturing and curing be done in the most approved manner, else the block will not have sufficient density to make it moisture proof. It is worth while, therefore, to urge upon block manufacturers the extreme importance of putting the best quality of materials and workmanship into silo blocks; and also to urge upon owners that they give careful attention to the blocks they are getting, contracting for them only with manufacturers who have the best reputation.

For the manufacture of silo blocks a clean, well graded sand should be used, and the mixture should be 1 part cement to 3 parts sand. The mix should be made as wet as the molds will allow, and should preferably be cured by steam, taking care that the blocks are not allowed to dry out before having the steam turned on them. Additional waterproofness can be secured, if necessary, by the addition of some good waterproofing substance to the concrete when it is made, or by the application of an inside or outside



Two Decorative Silos of Ideal Blocks on the Barber Estate, Barberton, Ohio

coating, or both. A coat of cement plaster on the inside will be conducive to this end, and will also have the advantage of giving the silo a smooth wall.

In starting the construction of a concrete block silo, the excavation, floor and footings will be the same as for a monolithic silo. In starting the walls, however, some readjustment of the radius may be necessary in order to accommodate the construction to the size of units available. The length of silo blocks is not usually changed for the various diameters, so that in order to make it possible to use only whole and half blocks, or such fractions as the machine will make, and thus avoid cutting, it will be well to lay out a test circle after the footings are in and see how closely the blocks conform to the desired size. The circle can then be made slightly larger or smaller to accommodate them.

The cement mortar should consist of 1 sack of Portland cement to 2 cubic feet of clean sand, with the possible addition of a small quantity of hydrated lime (not over ten per cent), to make it easier to work. Before laying up the blocks, see that they are thoroughly soaked which will prevent them from drawing moisture from the mortar. No more mortar should be mixed at one time than can be used up within 30 minutes after first moistening.

Most blocks now made for silo work have some provision for continuous reinforcement; but if such provision is not made, reinforcing wire must be used between the courses of blocks. A table herewith gives the amounts of reinforcing necessary for block silos.

The doors in a block silo are installed similarly to those in silos of other types. For intermittent doors, frames 6 inches wide of 2-inch lumber are placed at proper intervals in the 8-inch wall. This leaves a 2-inch recess on the inner surface of the wall in which will set the wooden door. Vertical steel rods are set in mortar in airtight spaces of the block next each side of the doors, and the horizontal reinforcing hooked around them. Sufficient extra rods are placed across

Block Silo at Atlanta, Ill.

the top and bottom of the door to equal the horizontal rods which are cut out by the door opening.

For a continuous door, a vertical concrete frame is sometimes cast on each side of the door opening. In

TABLE IX—Giving Horizontal Reinforcement for Block Silos, Showing Size of Wire or Round Rods to be Used Between Each 8-inch Course of Blocks

Ft. from top of Silo	Diameter of Silo in Feet							
	8	10	12	14	16	18	20	22
0— 4	No 6	No 6	No 6	1/4 in	1/4 in	1/4 in	1/4 in.	1/4 in
4— 8	No 6	No 6	No 6	1/4	1/4	1/4	1/4	1/4
8—12	No. 6	No 6	1/4 in	1/4	1/4	1/4	3/8	3/8
12—16	No. 6	1/4 in.	1/4	3/8	3/8	3/8	3/8	3/8
16—20	1/4 in.	1/4	3/8	3/8	3/8	3/8	3/8	3/8
20—24	1/4	3/8	3/8	3/8	3/8	3/8	3/8	3/8
24—28	3/8	3/8	3/8	3/8	3/8	1/2	1/2	1/2
28—32	3/8	3/8	3/8	3/8	1/2	1/2	1/2	1/2
32—36	3/8	3/8	3/8	1/2	1/2	1/2	1/2	1/2
36—40	3/8	3/8	3/8	1/2	1/2	1/2	1/2	5/8
40—44	3/8	3/8	1/2	1/2	1/2	1/2	5/8	5/8
44—48	3/8	3/8	1/2	1/2	1/2	5/8	5/8	5/8
48—52	3/8	1/2	1/2	1/2	1/2	5/8	5/8	5/8
52—56	3/8	1/2	1/2	1/2	5/8	5/8	5/8	5/8
56—60	3/8	1/2	1/2	1/2	5/8	5/8	5/8	5/8

R.F.

this frame are embedded the vertical rods, to which all the horizontal rods are hooked, in a manner similar to that described for monolithic silos. At other times angle irons or U-bars are used for frames, or special iron shapes, with offsets for doors are used.

A wooden or metal chute can be fastened to the walls or one can be built of blocks at the same time as the walls.

The roof of a block silo can be made either of wood or of concrete. When of concrete, the method of procedure is the same as that specified for solid wall silos, except that the temporary roof rafters rest on the wall, and the eaves are formed by a special block which gives the necessary overhang.

Below are given brief descriptions of a number of the systems of silo block construction now available.

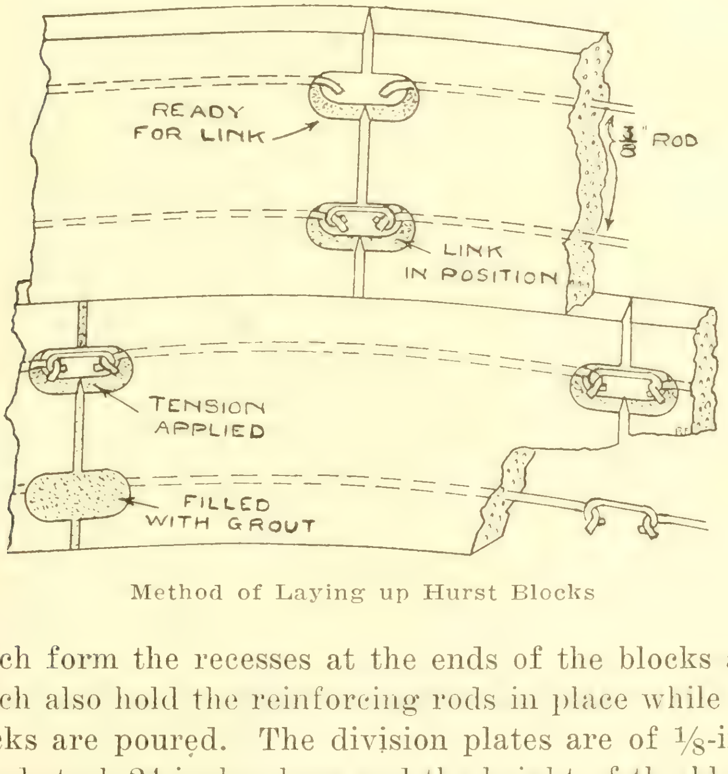
Hurst System. This system is marketed by the Hurst Silo Equipment Company of Chicago. The unit of construction is a solid block 23½ inches long, 11¾ inches high, and 4 inches thick. Each block is reinforced with two ⅜-inch round rods, the ends of these rods projecting into recesses at the end of each block and being bent into a hook to receive a steel link. When the blocks are laid up in the wall, the ends of rods in adjoining blocks are thus brought together, and after the link is slipped over them the ends are bent back by means of a tool supplied for the purpose. This makes the reinforcing continuous around the structure, and the process of bending up the rods serves to bring the steel into tension and thus resist the pressure of the silage when the silo is filled. The recesses which hold the links are afterwards filled with mortar, as well as the V-shaped joint between the blocks on their inside surface.

TABLE X—Showing Number of Blocks Required for Various Sizes of Silos. Whole Blocks 8x8x16 inches. Door 3 ft. 10 in. wide

Inside Dia. of Silo	10 Feet		12 Feet		14 Feet		16 Feet		18 Feet		20 Feet		22 Feet	
Size of Block	Whole	Half	Whole	Half	Whole	Half	Whole	Half	Whole	Half	Whole	Half	Whole	Half
Height 26	897	39												
28	966	42	1155	42										
30	1035	45	1238	44	1463	44								
32	1104	48	1320	48	1560	48	1776	48						
34	1173	51	1423	50	1658	50	1887	51	2117	50				
36	1242	54	1485	54	1755	54	1998	54	2241	54	2511	54		
38	1311	57	1568	56	1853	56	2109	57	2369	56	2651	56	2907	57
40	1380	60	1650	60	1950	60	2220	60	2490	60	2790	60	3160	60
42			1733	62	2048	62	2331	63	2615	62	2999	62	3213	63
44			1815	66	2145	66	2442	66	2739	66	3069	66	3366	66
46			1898	68	2243	68	2553	69	2864	68	3209	68	3519	69
48			1980	72	2340	72	2664	72	2988	72	3348	72	3672	72
50			2063	74	2438	74	2775	75	3113	74	3488	74	3825	75
52					2535	78	2886	78	3277	78	3627	78	3978	78
54					2633	80	2997	81	3362	80	3767	80	4131	81
56					2730	84	3108	84	3486	84	3906	84	4284	84
58					2828	86	3219	87	3611	86	4046	86	4435	87
60					2925	90	3330	90	3735	90	4185	90	4590	90

R.F.

These blocks are cast in steel molds, each mold making ten blocks at one operation. A reference to the illustration here shown will give a very good idea of the assembling of the mold. Each mold consists of two sides, two sets of division plates, clamps for locking molds, and core covers. The sides of the mold are of pressed steel, fitted with hollow pressed steel cores,

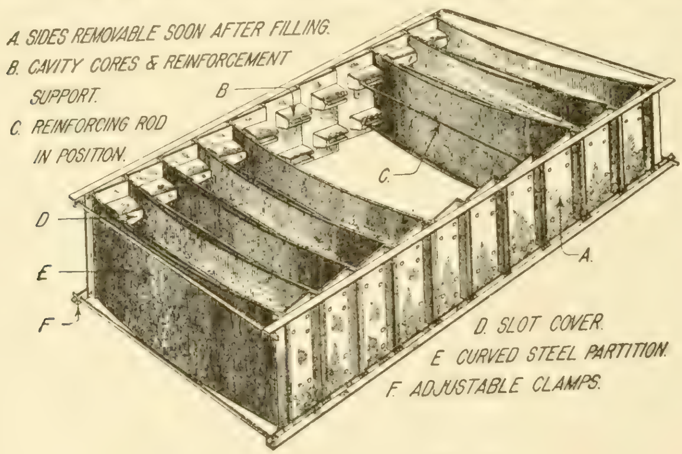


Method of Laying up Hurst Blocks

which form the recesses at the ends of the blocks and which also hold the reinforcing rods in place while the blocks are poured. The division plates are of ⅛-inch rolled steel, 24 inches long and the height of the block. These division plates are curved to conform to the diameter of the silo and can be furnished for any size. Short division plates are also supplied for making sectional blocks for "fillers." Two sets of standard division plates are furnished with each mold, so that it can be filled twice daily, making twenty blocks

A special bender for making the rods and links is included in the outfit if desired, or these will be furnished by the company to those who do not care to prepare their own. A bender can also be secured for changing dividing plates from one radius to another.

Iron or steel door frames are either secured from the company, or a pattern only is bought, allowing the contractor to have his frames made at the nearest foundry. All frames are curved to a radius of 8 feet, in order to avoid multiplication of parts, as the dif-



Hurst Silo Block Mold

ference of curvature is scarcely noticeable in the width of a door when this frame is used on other sizes. The frame provides a beveled rabbet for a wood door, and carries loops to connect with the reinforcing rods of the adjoining blocks.

Steps are bolted to the doors, or ladder steps of steel with ends flattened are embedded in the mortar between the courses of blocks.

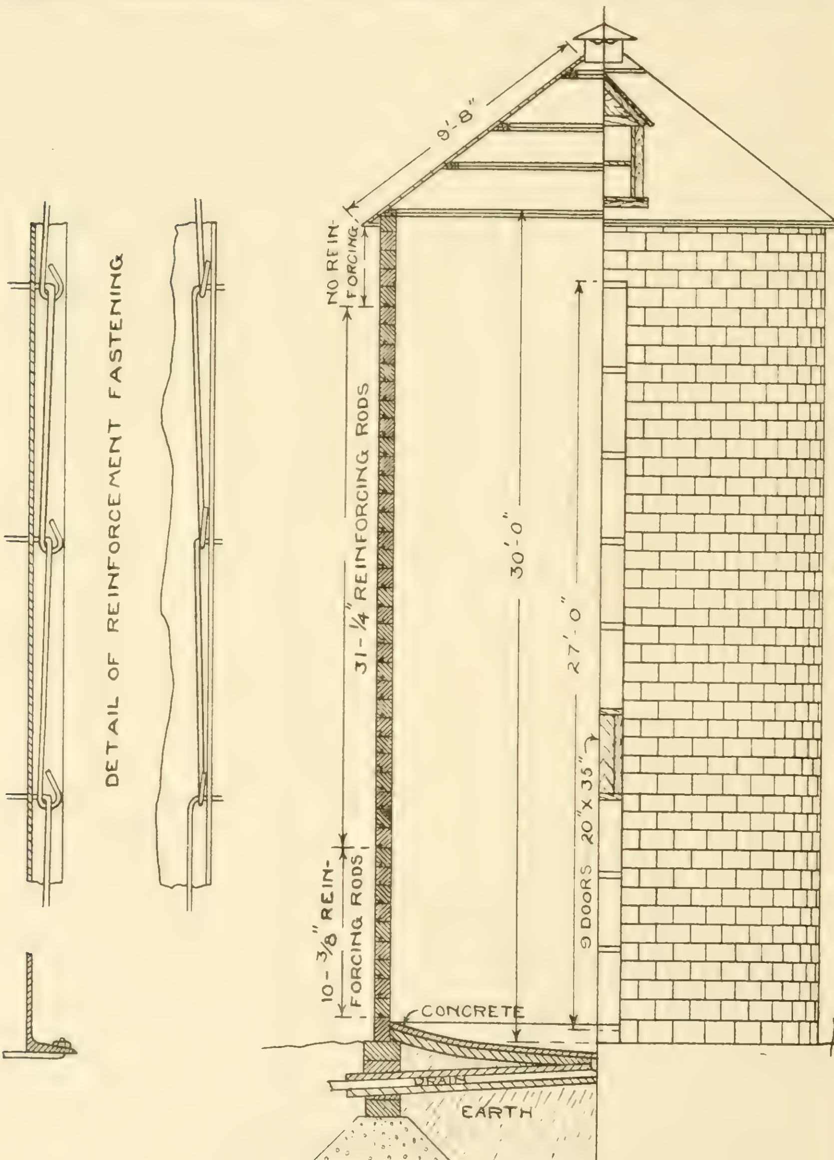
If a chute is desired, ½x5-inch bolts are inserted in every third mortar joint on either side of the door frames, beginning 8 feet from the ground. Similar bolts also extend upward every 4 feet in the joints of the top course of blocks, to anchor the roof, which may be of any type.

Dove-tail Silo Block. The Lansing Company, Lansing, Mich., manufacture what is called the Dove-tail silo block machine. This machine makes a hollow silo block with dove-tail openings at each end. Where these openings come together, they fit over a small countersunk hole in the middle of the block below. The dove-tail opening is filled with soft mortar which finds its way into the countersunk hole and binds the blocks together both horizontally and vertically. A small groove is also provided in the top of each block for the purpose of laying in reinforcing wire.

Dove-tail Silo Block.

The machine consists of a base and a flask or mould. The mould consists of a front and back plate, two end plates, center cores, dove-tail end cores, extra face plate for half size blocks, and dividing plate. The two end plates fit into lugs in the front plate and the back plate is held in position by two end levers. The mould is of the self-truing type and will produce blocks of an attractive design. It is furnished in 12, 14, 16 and 18-foot diameters. Each size of block can also be used for a silo of a diameter 2 feet larger than the stated size. It is equipped for either 9 or 10-inch blocks, 16 inches long, 8 inches high. The regular equipment consists of rock face design, but the manufacturers also furnish a plain design.

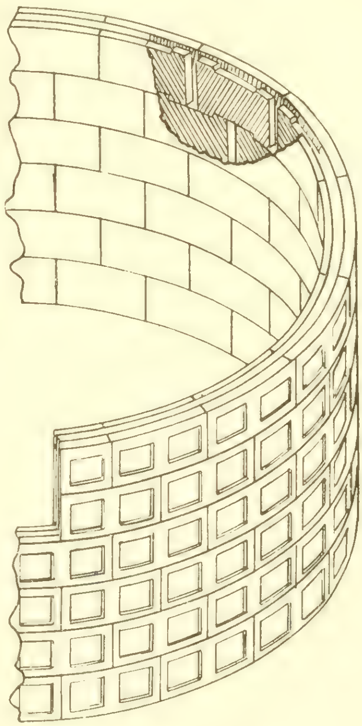
Ideal System. The Ideal Concrete Machinery Company, Cincinnati, Ohio, supplies molds for silo blocks



Method of Constructing Ideal Silos

in the standard 8x8x16 inch size in practically all the faces designed by this company for straight building blocks. These silo attachments can be set on the standard Ideal block machine base outfit, and the silo blocks are cast with two 4x6 inch core openings the same as the building blocks. Attachments are provided for making blocks on a 5, 7 or 9-foot radius.

As each block is cast, a piece of half round iron makes a groove in the top, about 1 inch from the outside face, this groove accommodating the reinforcing ring when the blocks are laid up. These rings are fastened at the ends to the door frames as shown in the illustration; or if the builder has at hand the proper dies for cutting threads, he can thread the ends of each ring and draw the ring to the proper tension with a nut.



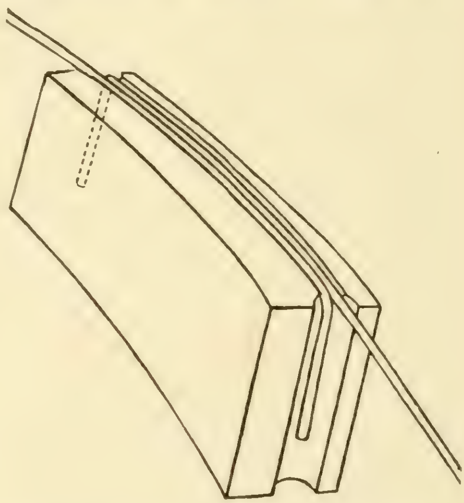
Climax Blocks

The door frames consist of U-bars for uprights connected at 3-foot intervals by 4-inch I-beams. The uprights are set just the thickness of the door from the inner face of the block, so that when the door is in place the interior will present a smooth surface.

It is recommended that the inside of the silo be plastered with cement mortar, applied preferably with a trowel, and then going over the entire surface with a stiff brush and cement grout.

Climax Silo Blocks. The equipment for making these blocks is furnished by the Climax Manufacturing Company, Anderson, Indiana. The blocks are 20 inches long, 10 inches high, and 4 inches thick. Each block carries lugs on the underside and recessed groove on the upper side, holding the blocks in perfect position when they are placed together. The blocks themselves are reinforced with any wire available, and a No. 9 wire is also used in the grooves as the blocks are laid up.

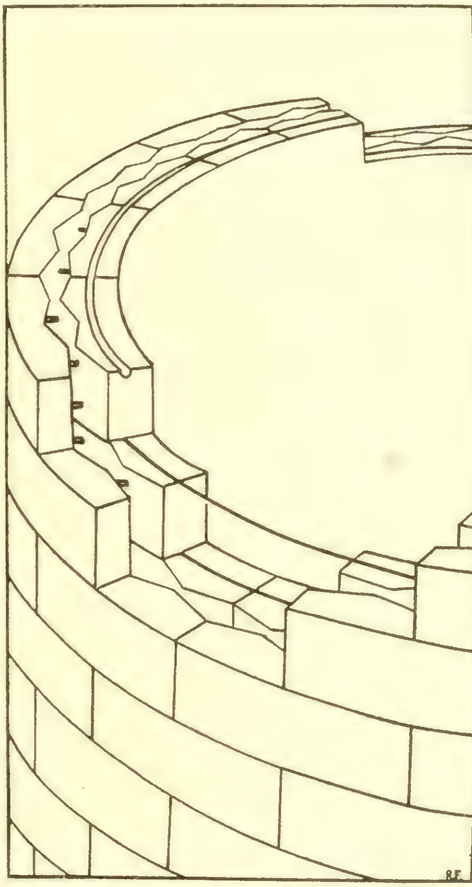
Kenny System. The Kenny concrete blocks are made with a groove in the top for receiving the reinforcing rod, which is continued in one piece around the entire silo, locking it over a key block, as shown in the accompanying cut.


Wires Locked Over Key Block

The vertical grooves in the ends of the blocks form an opening 2 inches in diameter between the blocks when laid in the wall; this opening is filled with cement mortar.

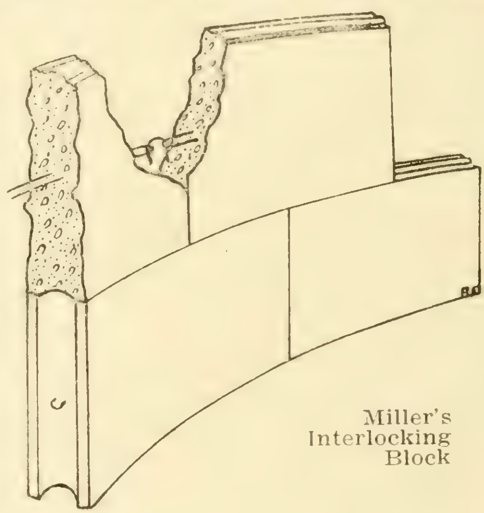
The blocks are made on a double machine, turning out two blocks at one operation, and are 24 inches long, 8 inches high, and 4 inches thick.

Anchor Silo Blocks. This block makes a double wall, with a continuous air space. It is controlled by the Anchor Concrete Stone Company, Rock Rapids, Iowa. Each block is made in two separate sections, bound together with four ¼-inch galvanized iron rods, 8 inches long and turned 1 inch at each end. The Standard Anchor machine makes a block 8x8x 24 inches, while the Junior Anchor machine makes a block 8x8x16 inches. Each machine makes blocks to fit any desired radius of silo. This is accomplished by having the mold box equipped with inside steel plates which can be adjusted by set screws to the desired curve. The interior section of the block is cast with a groove in the top in which reinforcing can be placed.


Anchor Blocks Laid Up in Wall

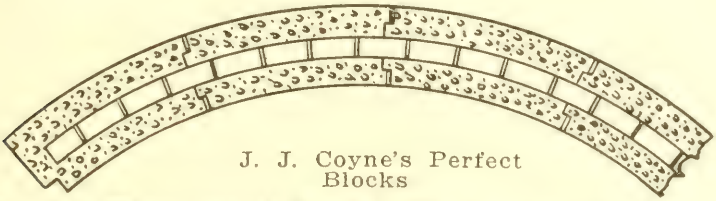
Keystone Cement Slab Silo. This system is controlled by the Minnesota Keystone Silo Company, Minneapolis, Minn. The blocks or slabs used in a Keystone silo have a special design, the ends being wider by 3 inches than the center of the slab. This, in addition to the tongue-and-groove edges, makes of each block a key which securely locks the adjoining slabs. The slabs or blocks are 24 inches long, 3 inches thick, 16 inches wide at the center and 13 inches at the middle. Each block is reinforced with two 3/8-inch steel rods, each end of each rod projecting into a small cavity. When the blocks are laid up these ends are connected and brought to tension by a special tool. The cavity is then filled with concrete.

Millers' Sectional Interlocking Block Silo. This system is controlled by the Goshen Concrete Tile Manufacturing Company, Goshen, Indiana. The blocks in this system are solid blocks made of slush concrete interlocking at all edges. A double rod of 5-16-inch iron through each block makes the reinforcing and forms an eye at the end of each block. The blocks are fastened together by means of a staple passing through these eyes, the open spaces around the eyes and staples then being filled with mortar. The door frame used in connection with these blocks is constructed of channel iron. On the side of the door jamb toward the block, there are eyes every 12 inches to correspond with the eyes on the block, so the door frame and blocks are locked together by means of staples and spaces filled with mortar, making joints same as between the blocks themselves.



Miller's Interlocking Block

Perfect Cement Blocks. This is made on the perfect cement block machine, manufactured by J. J. Coyne, Fond du Lac, Wisconsin. This machine makes a hollow block of two types, the two parts in the block being connected either by a web of concrete or by steel spacers. The blocks are made 8 inches high, 9 inches thick and 24 inches long, with 2½-inch air space. The blocks interlock in both directions and have a groove on top for reinforcement.



J. J. Coyne's Perfect Blocks

Perfect Reinforced Block. This system is the product of the Perfect Reinforced Cement Silo and Cistern Company, Delaware, Ohio. The Perfect Silo is built with blocks 2 feet long, 1 foot high and 4 inches thick.

Each block is reinforced with two iron rods running lengthwise of the block, 6 inches apart. Each rod is looped or turned 6 inches from the end. These loops in the rods coincide with the holes that are formed edgewise through the block, 1 inch in diameter and 6 inches from either end. In laying the blocks these 1-inch openings are filled with cement grout and the rod or dowel pin is pressed through the soft cement, connecting the two blocks. Each pin is inserted in such a way that it passes entirely through one block and half way through the block above and the one below. By this arrangement of loops and dowel pins, inserted in the holes through the blocks, and the use of half blocks, joints are broken in the same way as when an ordinary brick wall is laid. This provides for a continuous lateral reinforcement around the silo every 6 inches, and the dowel pins that run through the blocks from the bottom to the top of the silo form a vertical reinforcement every foot. A strip of netting composed of 7 longitudinal and 12 vertical steel wires, imbedded in the block just beneath the outer surface, is designed to prevent any liability of cracking of the face of the block. To unite the blocks and to overcome the outward pressure or thrust, a 2-ply twisted steel cable of No. 8 wire is laid outside the dowel pins between each course of blocks, in grooves provided in the edge of the blocks for that purpose, and imbedded in the mortar in which they are laid. The ends of these cables are looped about a continuous gas pipe, which extends from the top to the bottom of the structure, through the blocks each side of the doorway, in place of dowel pins. This same gas pipe also passes through holes in the ends of the ladder rounds.

Zagelmeyer System. This method of making silo blocks is the invention of the Zagelmeyer Cast Stone Block Company of Bay City, Mich., and is identical with the system used by this company for making building blocks, except that the silo blocks are made to fit the curve of the silo instead of being straight. The molds, which are of sheet steel, are assembled in multiple form on roller bearing trucks, each truck carrying molds for thirty silo blocks. The truck is then carried under the discharge end of the mixer and filled with slush concrete.

Each block carries two air spaces, and has a depression in the top for carrying a continuous circle of reinforcing around the silo.

Molds are made in both rock face and plain. The blocks can if desired be given a granite or other ornamental face, similar to the Zagelmeyer building blocks.

CHAPTER XVII

Doorways, Doors, Roofs, Etc.

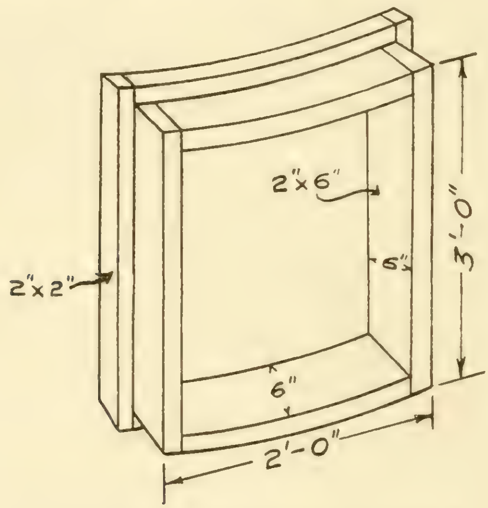
These topics have been dealt with in connection with some of the systems treated, so that in this chapter it is scarcely necessary to do more than take up some general features of these parts of the silo.

Doorways. Doorways are of two types, known as intermittent and continuous. These doorways are both good, and it is a matter of individual preference as to the one to select, although the separate openings are preferred by a great many silo users. These openings are usually 2 feet wide and 3 feet high, and are spaced about 3 or 4 feet apart. This type of doorway makes a stronger wall, but more difficulty is experienced in removing the silage for feeding than with the continuous door.

An easily constructed intermittent door form for a solid concrete wall silo is suggested by the Association of Portland Cement Manufacturers as shown in the illustration. Make a frame of 2x6 inch lumber as shown. Then prepare a second frame of 2x2 pieces, and nail it around the first. This will provide an offset or jamb of 2 inches in the concrete, to receive the door from the inside. This form should be made so that it will fit closely between the inside and outside wall forms.

The method of constructing a form for a continuous door opening is similar to the one for separate openings. Two pieces of lumber 2x6 inches are cut 5 feet long. Two holes are then bored through each piece.

These holes are 2 feet apart and 2 inches from the edge. The pieces are then ripped through the holes. A piece of 2x2 inch lumber, beveled, is then nailed to the 4-inch piece thus made. Cleats are nailed across the two pieces which were cut. These cleats are to hold cross-strips between the two uprights, for the purpose of keeping the door forms the right distance apart.

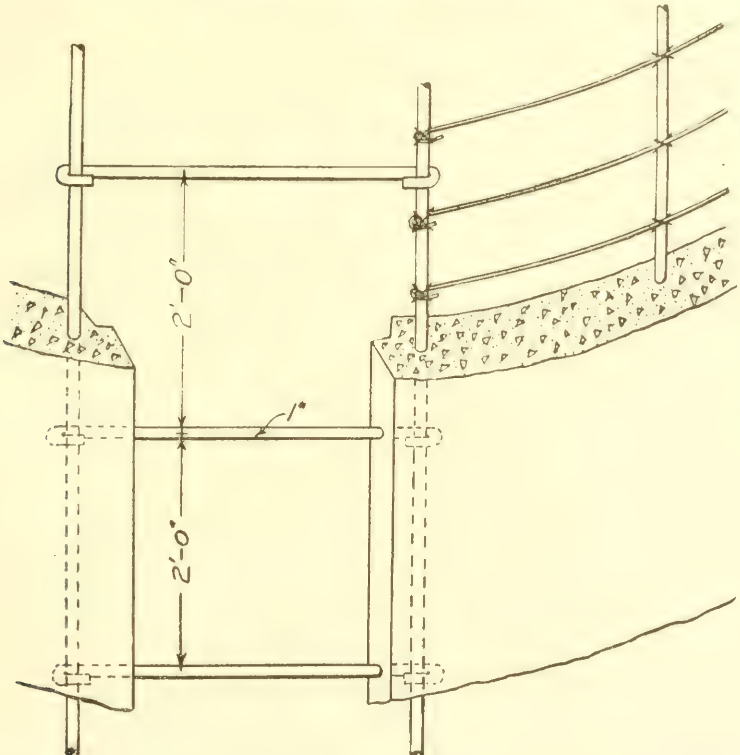


Form for Intermittent Doorway.

When setting the form into the molds, the ladder or door rods are placed in the holes of the door form. This method of door-jamb construction has been in use for eight or ten years, and has been found satisfactory. The method of reinforcing across both types of door openings is also shown herewith.

Doors. The doors for the continuous doorway may be made of 2-inch planking, preferably tongue-and-grooved. The doors should be 34 inches in width and 30 inches in height. Five pieces of planking 6 inches wide, or 4 pieces 8 inches wide may be used conveniently. A ⅜-inch hole is drilled on the vertical center line of each plank to accommodate the bolt and hook by which the door is held to the horizontal reinforcing across the door opening. The bolts used have a screw eye on the outer side to which hangs a hook made of heavy steel wire.

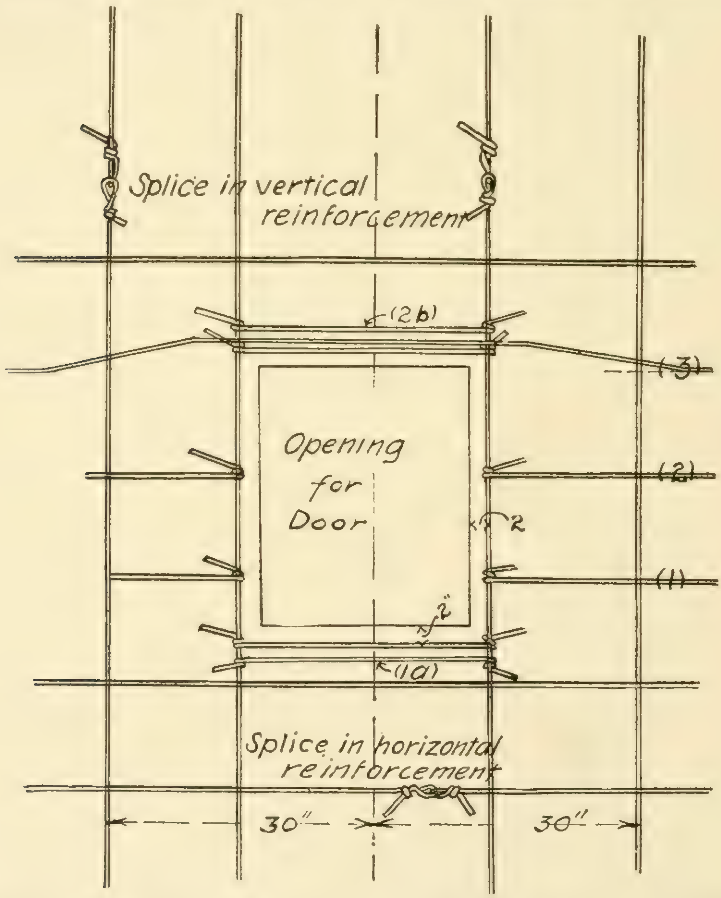
Non-continuous doors are perhaps easier to build than continuous doorways, and if the owners are satisfied that they provide sufficient room for getting the



Method of Fastening Reinforcing When Silo Is Built With Continuous Door Opening.

silage out conveniently, there is no objection to their use, although on the other hand, they possess no great advantage over doors of the continuous type. The arguments often heard that the non-continuous door silo is a stronger type than the other, and vice versa, carry little weight, as either type may be made sufficiently strong.

Non-continuous doors are often put in with a distance of about 2½ feet between them, but the spacing may vary to suit the individual owner. In all cases the arches between the doors must contain an amount



Method of Reinforcing Around Intermittent Door Openings.

of reinforcing equivalent to the full amount of horizontal reinforcing put around the silo. Thus, if the doors are 3 feet in height, with a distance of 2½ feet between them, the horizontal reinforcing in the space between the doors should be equivalent in amount to that placed in 5½ feet of the wall where there are no doors.

The doors may best be made of two thicknesses of 1x6-inch matched flooring with a layer of tar paper between. The 1x6-inch boards are held together by two 1x4-inch cleats across the top and bottom, and one 2x4-inch cleat across the center. The middle cleat is made larger than the others in order to take care of the strain caused by the large bolt in the center. A 2x4, 40 inches long, or a similar piece of material, is placed on the bolt, making a large "button" by which the door is held to the wall.

The Roof. Perhaps the greatest advantage of a roof is the lessened liability of the silage freezing. Not only is it impossible to prevent freezing in severe weather unless the silo is provided with a roof, but during snowy or rainy weather the silage is mixed with snow or wet down with rain. Furthermore, a silo without a roof becomes a catching place for husks, dust or anything carried in the wind and a favorite feeding ground for the neighborhood pigeons and birds. Although many silos are not provided with roofs and the live stock eagerly eat the silage from them, it is evident that a roof would not only reduce the amount of frozen silage, actually save silage and preserve its quality, but be worth its cost in making a more pleasant place to feed from in bad weather. The roof is also valuable in protecting and strengthening the silo and in adding to its appearance.

A door for filling, large enough to admit the carrier or elevator from the ensilage cutter, should be placed in the roof. A simple trap door may be used for this purpose, but a dormer window with glass is preferable. Some light should be admitted to the silo for if not it will be necessary to use a lantern when removing the silage.

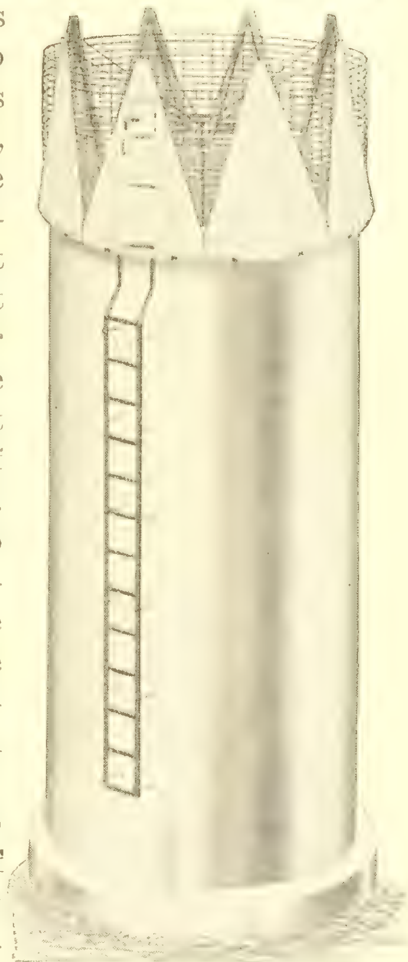
The pitch of the silo roof may vary from one-quarter to one-half. The steeper roof permits the silo to be filled above the top of the wall so as to be nearly full after settling. A flat roof does not permit the silage to be elevated to a point high enough to do this, does not give the workman room for work during filling, and does not shed the snow like a steeper roof.

While roofs of various types are used with concrete silos, it is most desirable that the roof be of concrete, thus making this part of the silo as durable as any other.

In some systems, special roof forms are provided; but where there are not obtainable a concrete roof can be laid 4 inches thick over a temporary wooden form, which will be left in place two or three weeks. The concrete should be reinforced with steel rods ⅜-inch in diameter. Some of the rods are laid like the spokes of a wheel, 1-inch from the under side of the roof. At the eaves the rods are 18 inches apart; but every other rod runs only half-way to the peak, where it is tied to a horizontal ring extending entirely around the roof. There are four of these horizontal rings equally spaced from the eaves to the center of the roof. Where the straight or radial rods meet at the peak they should be hooked and securely tied together. In the eaves an additional ring is placed, around which are hooked the outer ends of the straight rods.

Eaves on a concrete roof are not absolutely necessary, but add much to the appearance of the silo.

Iron Roof. An iron roof for silos is made by the C. C. Fouts Company, Middletown, Ohio. This roof is made in sections readily bolted together. It is of pure iron, 20 to 24 gauge, and is equipped with a large trap door for filling. This door fits over a raised rim in the roof, making it weatherproof. These roofs are made with a ventilator and a heavy wired glass at the top, admitting sufficient light to light up the interior of the silo. One advantage of this kind of a roof is that sections of it can be left off while the silo is being filled. This will allow of the silo being filled to its full capacity, while the settling of the silage will be sufficient to give working room when it is desired to begin feeding from the silo.


Winner Silo Roof

Winner Extension Silo Roof. The special feature of this roof, which is made by the Silo Specialty Manufacturing Company at Clinton, Iowa, is that it allows the user to utilize the entire space of the silo. That is, the roof opens outward from the peak, so that the silo can be filled above the height of the walls. As the silage settles the roof is closed, giving the contents of the silo complete protection against the elements.

The method of operation of this roof is well shown in the illustration. It has a metal roof consisting of separate segments which are hinged at the bottom and can be opened until they stand vertical. When they are opened for filling the silo the spaces between the segments are protected by wire mesh.

Buckeye Silo Roof. This is a sheet metal roof, made in gambrel design with dormer window. It is made by the Thomas & Armstrong Company, London, Ohio. The same company also makes all-steel silo doors, and other silo equipment.

Air-Tight All Steel Door Frame. This is a continuous door manufactured by the Silo Specialty Manufacturing Company at Clinton, Iowa. This is an inflexible, unbreakable, steel door frame, requiring no packing to make a tight door.

CHAPTER XVIII

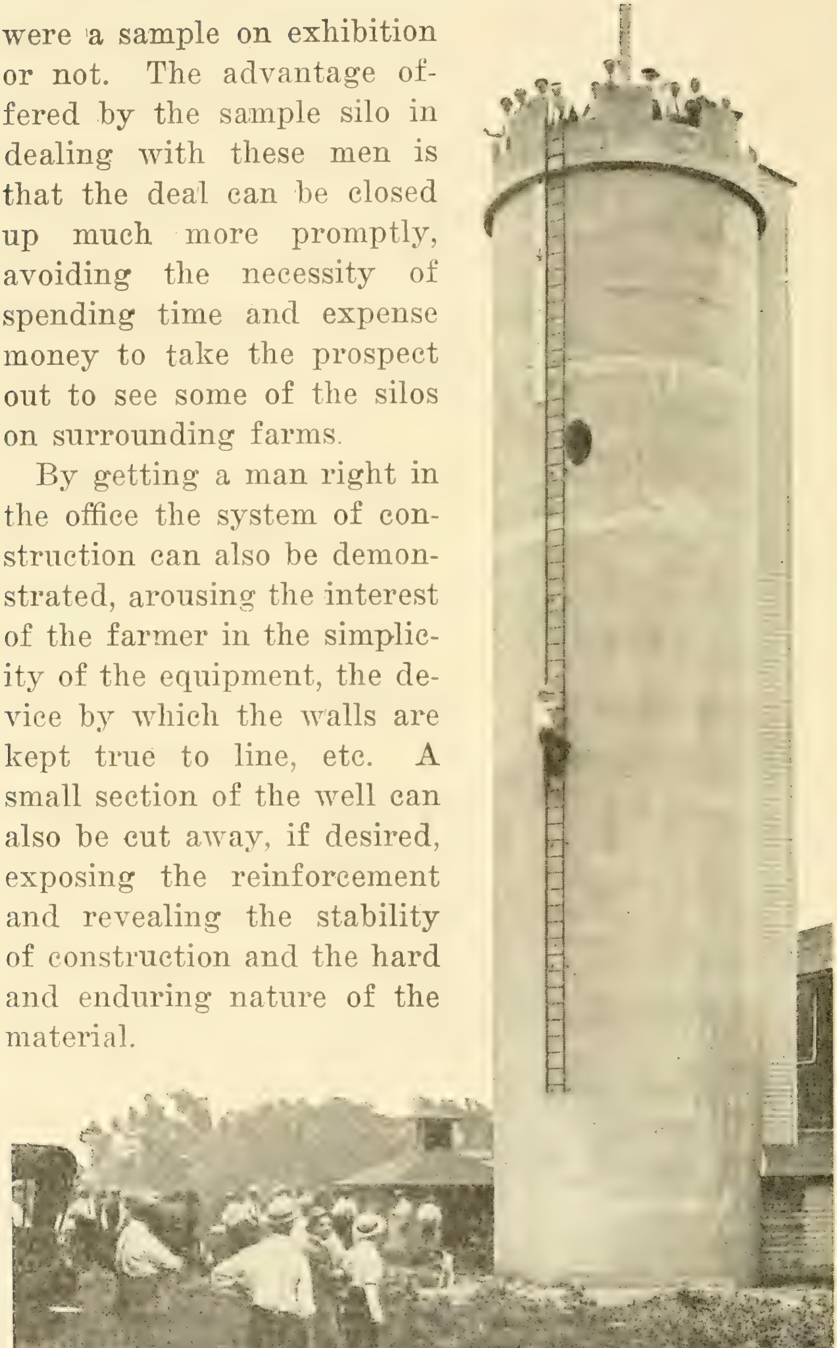
How to Increase the Silo Business.

A firm of contractors and supply dealers in Sioux City, Iowa, have adopted a novel method of promoting the silo end of the business by erecting a sample silo on their grounds and utilizing the lower part of it for office purposes. This company is fortunately situated at the stock yards, within 75 feet of the Live Stock National Bank, so that the silo is just where it will catch the attention of the men it is desired to reach. It carries a conspicuous sign, calling attention to the fact that the structure is for inspection and that the office is inside. Leaflets are also sent out among the farmers in the territory telling them of this exhibition silo and showing illustrations of it and also of silos which the company has constructed on farms in the vicinity.

The sample silo has at least two advantages as an advertising asset. There is no doubt but many farmers will be attracted by it and will step in "just to look around" out of curiosity. If the sales work is what it should be, a fair proportion of these will ultimately buy. The prospective customer is thus brought right to the office instead of making it necessary to go out after him, and any salesman knows what this means, both in the saving of time and the advantage of having the man on your own ground and with a confessed interest in what you have to sell.

There will be still other men who know that they want a silo and would come to the office whether there were a sample on exhibition or not. The advantage offered by the sample silo in dealing with these men is that the deal can be closed up much more promptly, avoiding the necessity of spending time and expense money to take the prospect out to see some of the silos on surrounding farms.

By getting a man right in the office the system of construction can also be demonstrated, arousing the interest of the farmer in the simplicity of the equipment, the device by which the walls are kept true to line, etc. A small section of the well can also be cut away, if desired, exposing the reinforcement and revealing the stability of construction and the hard and enduring nature of the material.



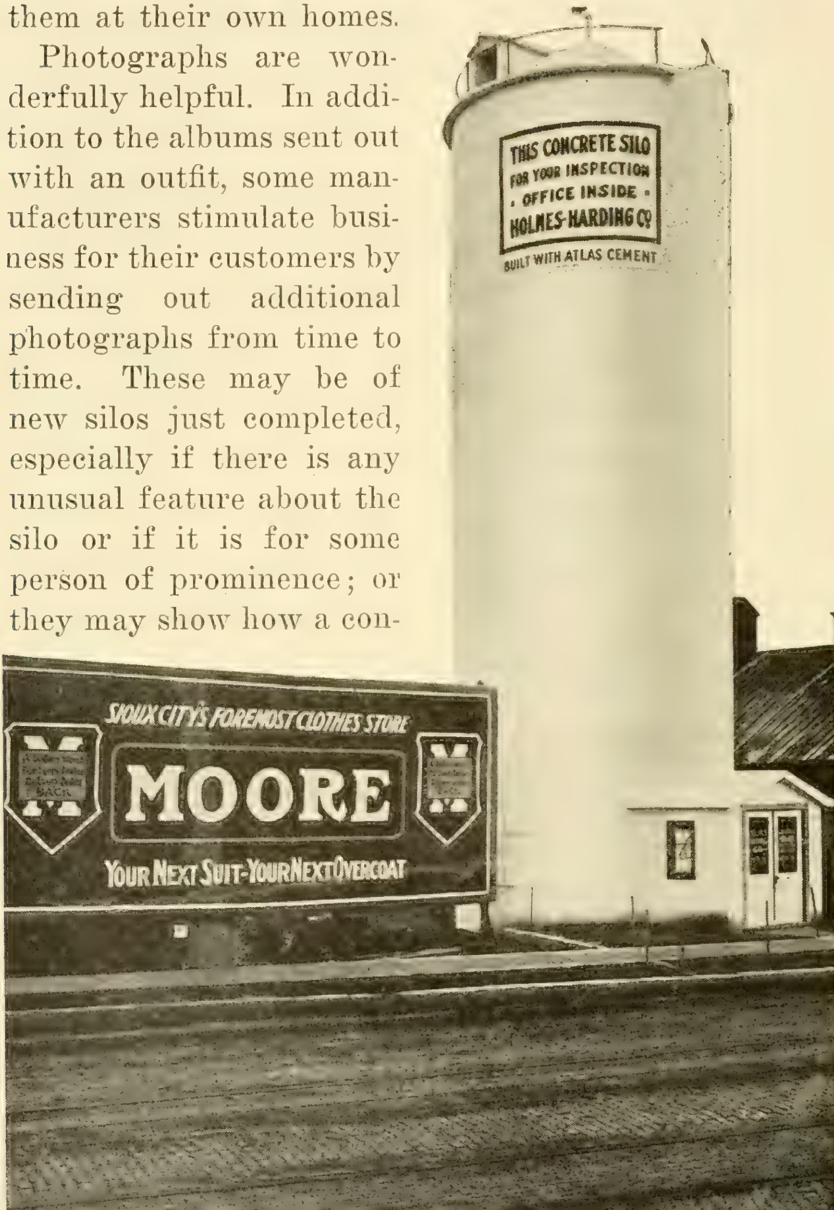
Silo Inspection Trip Conducted by a Cement Company.

While a sample silo of this kind costs a little money, where a favorable location can be secured it would seem to be a very valuable advertising asset; and especially would this be true in thinly populated districts, where a contractor, located in a central market town, can bring to his office men whom he would otherwise have to go many miles to reach.

Sample silos of a permanent nature are located on the grounds of many of the state fairs, while temporary sample sections are frequently put on display at various expositions. These are usually put up by the promoters of the various systems of construction, and they serve the double purpose of stimulating a demand for silos and of reaching contractors and interesting them in this class of construction.

Some of the more progressive manufacturers have well devised campaigns which are put into effect for the benefit of contractors who buy their outfits. In addition to furnishing him with suitable printed matter, albums of photographs, etc., each contractor is requested to send in to the company the names of farmers in his locality who should own silos—not a miscellaneous list of names, but a list which is carefully selected and not too large to have devoted to it some personal work on the part of the contractor himself. To these people the manufacturer sends out a letter setting forth the advantages of concrete silos in a brief way and calling attention to the fact that the local contractor is now prepared to build such a silo for them. These letters are followed up at suitable intervals by letters sent out by the contractor, but the copy for which is supplied by the manufacturer; and in the mean time it is expected that the contractor is doing more or less personal work with these people, at least to the extent of taking advantage of casual meetings when they are in town if he does not get out to see them at their own homes.

Photographs are wonderfully helpful. In addition to the albums sent out with an outfit, some manufacturers stimulate business for their customers by sending out additional photographs from time to time. These may be of new silos just completed, especially if there is any unusual feature about the silo or if it is for some person of prominence; or they may show how a con-



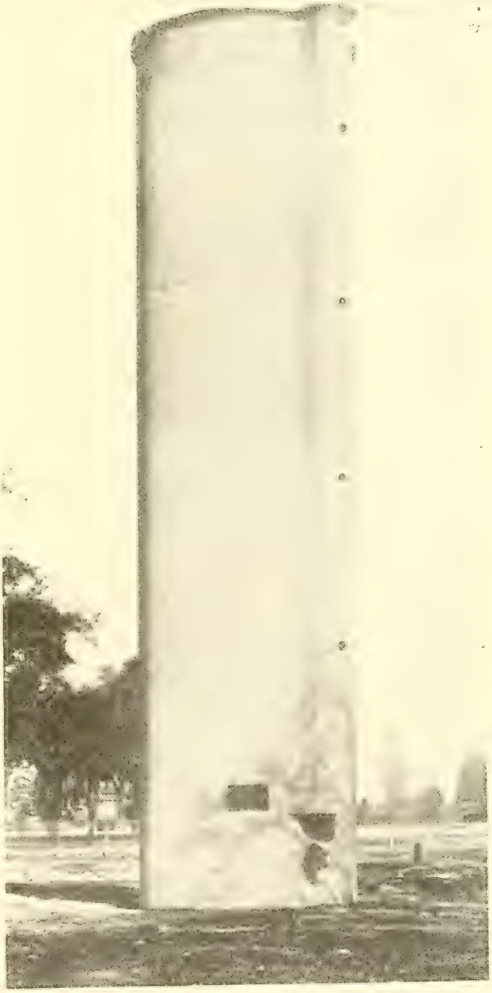
Sample Silo and Office at Sioux City, Iowa.

crete silo has successfully withstood a recent fire, tornado or earthquake.

The contractor can also assist in this part of the work by having photographs made of the silos which he erects and using them in his own local work as well as supplying them to the manufacturer for the betterment of the industry as a whole.

Some silo builders have secured permission from their customers to place at the entrance to the farm a neat sign bearing an inscription something like this:

> **The Concrete Silo**
> On This Farm Was Built by the........ Company. Drive in and Examine It.



Silo on Illinois State Fair Grounds.

In most localities the principal opposition to be combated is from the wood silo. For the representative of this type is more frequent and more persistent than any other, and he is in fact the only silo salesman whom many a farmer sees. This is because the wood silo is a factory product, capable of being shipped out "ready made" under the supposition that the farmer can put it up himself, thus lending itself readily to the building up of a large sales organization. These agents who are sent out over the country know that their main business is to get orders, and an important part of their equipment for so doing is a handful of misinformation about concrete as a silo building material.

But with no knowledge to the contrary, a farmer is perhaps not to be blamed if he believes the man who assures him positively that the acids in silage will eat out a concrete silo in two or three years. It is necessary that this propaganda be combated, and the authoritative statements which have been given out by so many of the agricultural schools of the country should be given wide publicity, as they will go a long way toward forming in the mind of the user of silos a saner and more correct view of the situation. Statements of this nature can well be included in some of the printed matter sent out by contractors to develop the silo business; and editors of newspapers should be prevailed upon to print matter pertaining to silos from time to time.

It is generally conceded that advertising in local newspapers on the part of contractors will form a valuable adjunct to other forms of development work. If this advertising can be given a local turn at times, such as printing illustrations of silos which have been built in the neighborhood, or letters of recommendation from local men who are pleased with their silos, this advertising will have a double value.

A farmer can often be interested in concrete silos by having pointed out to him the fact that most of the materials can very likely be found right on his own farm and that he will be the gainer to that extent. One Iowa contractor has taken a somewhat novel way to emphasize this point. He says in his advertising:

> *If you have sand and gravel on your own farm or nearby, we will buy it from you.*

This representation to the farmer that he is going to get some of his money back immediately will prob-

Exhibition Silo at Texas State Fair.

ably be more convincing than would a mere statement of the saving effected by the use of materials from his farm.

A considerable amount of promotion work on all kinds of silos can be carried on during the winter, when the farmer is not so busy and is looking ahead to the improvement of his farm.

The farmer as a class usually looks farther ahead than any other man. Of course, there are farmers who live from hand to mouth, as the saying is, just the same as can be found in any other calling; but for the most part you will find among well-to-do farmers more accurately detailed plans for the future than among almost any other men that one might name. The very nature of their occupation leads them to plan that way. Practically nothing that a farmer does comes to fruition until a considerable time after it is started. In this sense he is always working for the future. His grain is planted in the spring and harvested in the fall; the kind of stock that he will raise is made the subject of serious study sometimes years ahead; the products of his farm must be stored away at certain seasons for future use; and his bank account, which is swelled at periods of the year when products are being sold, must be conserved to provide for the times when there will be no income.

It is perhaps for some of these reasons that concrete products manufacturers have found the farmer market a most satisfactory and profitable one. It might be mentioned also that the farmer is a good advertiser. He delights to make every business transaction the subject of conversation. Where the city business man will buy a thing in a hurry and promptly forget about it, the farmer will buy slowly and only after much discussion, and once having bought he will talk about his purchase for some time afterward. Sell him what he believes to be a good product and the chances are that you will soon get other orders from the same neighborhood; but if he believes that you have not treated him right, it will be very difficult to sell to any of his neighbors for some time to come.

In some localities the manufacturers of concrete silo blocks and staves have discovered that they can keep business going at a fairly brisk pace throughout the winter by showing the farmers the advantage of hauling these things in the winter time. In fact, it seems to have been the farmers themselves who first discovered the advantages of such a system; but the products men have not been slow to take advantage of it in a number of instances.

In one Wisconsin town a block manufacturer was asked a quotation on a certain bill of silo blocks, in the middle of winter.

"They will cost you 16 cents apiece," said the manufacturer.

"All right, I am satisfied," said the farmer; "I'll take the first load of them out with me today."

The block man was alive to the advantage of quick sales, but he, at the same time, did not want to rush his product out without sufficient time to cure, so he said:

"Those blocks are only eight days old. You had better leave them here for a couple of weeks longer and let them cure. If you take them now it is pretty sure there will be a number of them broken when you get them home."

"There is no time like the present," was the reply of the farmer, or words to that effect. "Today the weather is fine, the roads are smooth and well packed down, and I can carry just as many blocks as I can pile onto my sled. In two weeks there may be a thaw, or snowdrifts, or a spell of stinging cold, or a run of sickness in the family. I would rather take them now and stand the breakage myself. After I get them home they can cure just as well in my yard as yours."

And so the blocks were taken out immediately. Not many blocks were broken, but such as they were the loss was willingly borne by the farmer, for he had done the hauling in time which would otherwise have been almost a total loss, over good snow roads, doing the hauling with a sled, which is much easier to load and easier to haul than a wagon, and the blocks were on hand ready to begin work as soon as the first robin appeared.

From the standpoint of the block manufacturer, too, the transaction was a most satisfactory one. It helped him to keep his plant running during the cold season without unduly crowding the yard; it helped to distribute his yard labor over a longer period, and as the farmer had the money in the bank from the sale of his fall crops, and was glad to take advantage of a small discount, it helped the manufacturer to keep up the financial end of his business.

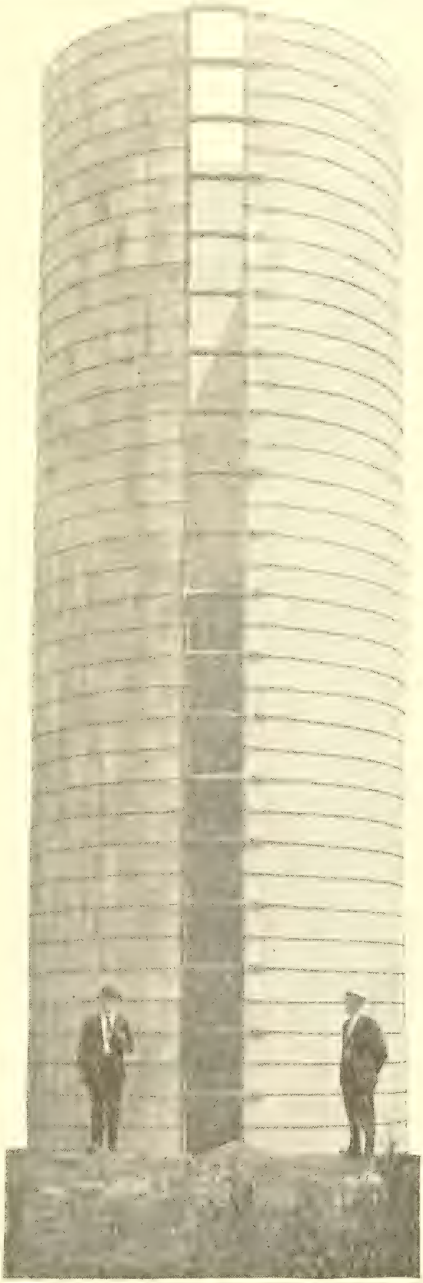
THE PERFECTION CONCRETE STAVE SILO

PERFECTION CONCRETE STAVE SILO COMPANY

516 CLAPP BUILDING, DES MOINES, IOWA.

There is only one way to manufacture concrete, and that is by the "Wet-Mix" process. Our Perfection Concrete Stave Silo Stave is made by the "Wet-Mix" process; the staves are cast in moulds with an aggregate of one of cement, two of sand, and three of gravel or crushed rock, and when cured, produce a strong, non-porous product and present a handsome appearance.

Our "all steel" large door system appeals to the farmer and silo users. We sell our moulds outright; we make no charge for royalties; there is no "blue sky" or exclusive territory connected with our proposition. You pay for what you get. In another part of this book is a complete description of our silo.



CONCRETE WORKERS

Get into the silo business. It furnishes splendid profits; it is a growing business. The silos you erect this year will be for many, many years to come "silent salesmen" for you. When you go into the concrete stave silo business, get the best. Get a system that permits making the staves by the "wet process"; that permits mortar to be placed between the joints of every stave; that will give you a malleable door frame with an all steel door and steel ladder combination; a silo without a word of criticism and easy to erect, and with splendid profits to the contractor. Write us for information, and we will gladly send you our literature. Excellent terms of payment to responsible people.

The Polk System

OF

Concrete Silo Construction

(MONOLITHIC)

PATENTED OCTOBER 23, 1906

PATENTED DECEMBER 29, 1908

Polk Genung Polk Co., Inc., Fort Branch, Ind.

INVENTORS AND MANUFACTURERS

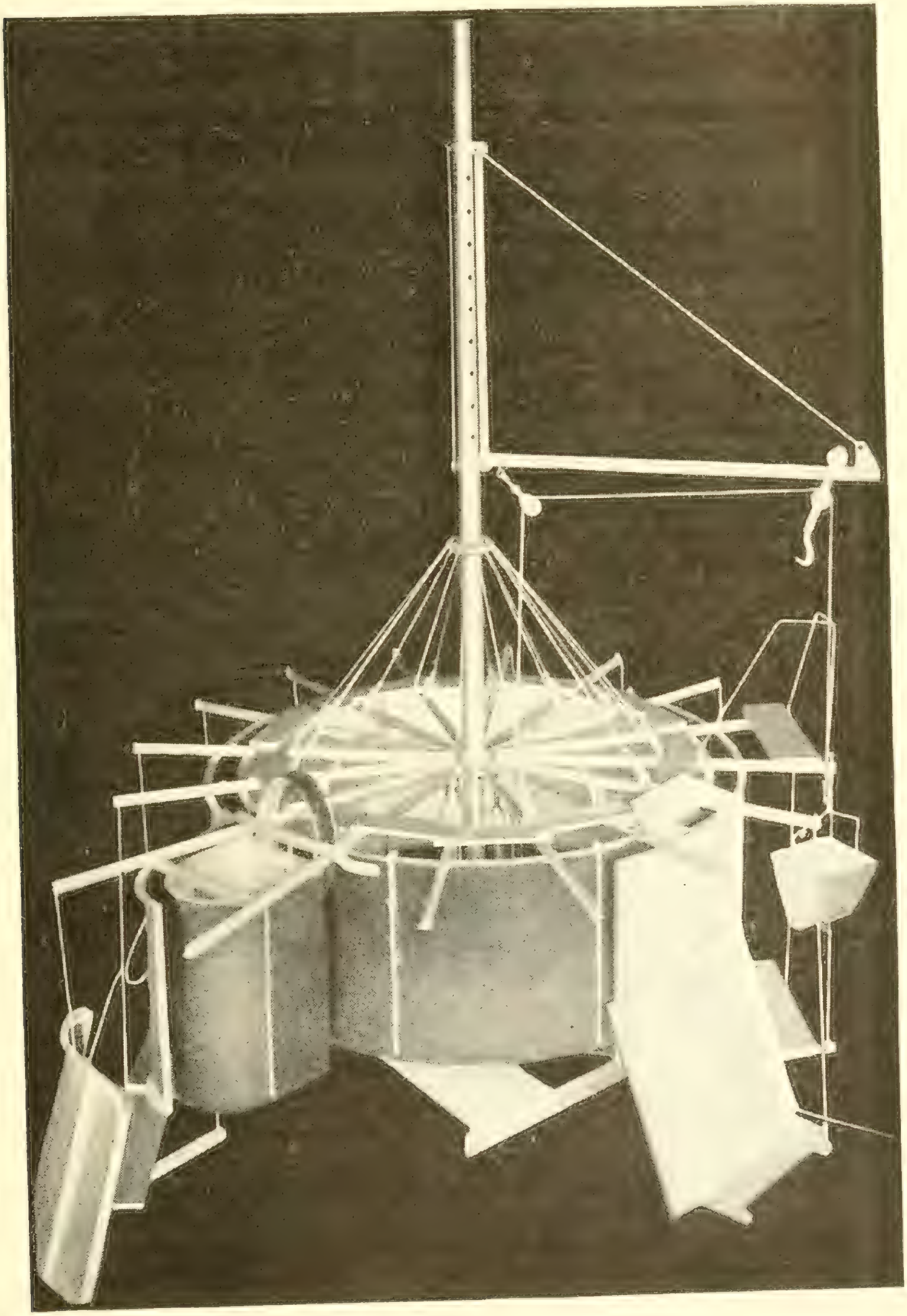
Opportunity Eventually concrete will displace all other material used in silo, water tank, and grain storage construction. Agricultural schools and experiment stations, bankers and insurance companies are backing concrete silo building. They are backing the POLK SYSTEM because it renders a distinct service in silo construction. Farmers have become prejudiced in favor of concrete silos because of their ultimate cheapness and of the lasting service they render. In the field of silo construction lies the greatest opportunity of the American contractor today.

The contractor who is equipped with a POLK SYSTEM machine and POLK SYSTEM methods can fully guarantee any building he erects. He has the assurance of a big, successful experience behind him. He knows that his work will please far beyond expectation.

Facilities The new POLK SYSTEM factory with its modern equipment enables us easily and economically to manufacture machines with every single excellence that years of experience have proved desirable. Not a single expense has been spared that will help to lower the cost of producing POLK SYSTEM machines and equipment and still maintain the high POLK SYSTEM standard of quality. We are putting on the market today the most thoroughly designed and the most durable machine that can be made for the erection of monolithic concrete silos.

Polk System Silos Are Not Built of Pieces

THE POLK SYSTEM MACHINE



and They Cannot Go To Pieces

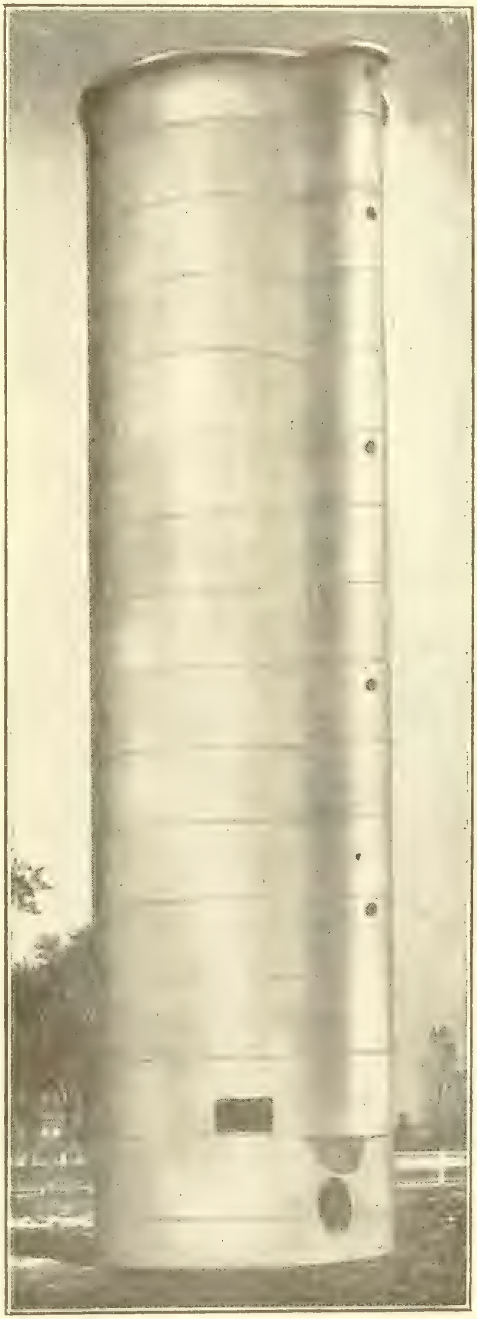
Description The POLK SYSTEM is in reality a completely detailed plan for all kinds of circular monolithic concrete construction. It specifies mixtures and proportions, it keeps the contractor abreast with the times, it reduces construction costs and insures a definite progress each day, and it makes provision for the safety of laborers. More than all of these, it insures to the farmer a flawless structure which will keep his silage secure against every known foe of good silage. **The POLK SYSTEM is much more than a mere machine.**

Machine The POLK SYSTEM machine is an all steel equipment for the erection of circular monolithic concrete structures. It has been developed with two things in mind—ease of operation and the production of absolutely flawless structures. The POLK SYSTEM machine automatically keeps the walls plumb, does away with an elaborate, complicated, risky system of scaffolding, imposes no strain upon the section of wall already built, and so unifies and simplifies construction that any intelligent workman can easily erect the most perfect, monolithic structure on earth.

The unifying, simplifying, protected principle of the POLK SYSTEM machine is the use of a centermast. This centermast is erected at the center of the floor of the structure and is carefully plumbed by means of guy wires attached to the top. It is a 4-inch steel pipe provided with a series of transverse holes to receive a heavy steel pin. This pin supports a widely flanged collar which serves to support the jack by which the forms are lifted.

Resting upon the jack is a hub, consisting of a flanged base collar and a top dished collar connected by a central pipe of sufficient diameter to work easily over the centermast. From the base collar of this hub radiate steel Tees which are supported from the upper collar by adjustable hanger rods with chain clevises.

The wall-forming forms are made in two widths—four and five feet. Each form consists of eight separable sections, each of which is reenforced and stiffened by a steel angle frame around the edges. The inner and outer steel wall forms are carefully rolled and tested for exact curvature. They are rigidly bolted to the radiating steel Tees. The outer sections are bolted together at their ends thru holes in the frames. The inner sections are similarly fastened together, but they carry a steel wedge between them, the lifting of which allows them to swing free. The fact that both inner and outer forms are securely bolted to the rigid steel Tees insures perfect curvature and alignment for every portion of the wall.



For placing the concrete in between the forms a V-shaped dumping bucket is used. This bucket is supported by a crane pivotally attached to the centermast directly above the top collar of the hub. It can be easily swung to any part of the wall space. It is hoisted by means of a rope and series of pulleys so arranged that the hoisting force is applied horizontally from without the structure. A small opening thru which the hoisting rope works is cut in the wall near the bottom of the first fill of concrete. When the bucket has been hoisted it is coupled to the carrier on the crane by means of a hinged hook. Then it is swung to any part of the wall space desired.

The scaffolding, both inner and outer, is swung from the steel Tees which project some distance beyond the wall.

Operation The operation of the machine is very simple. The forms are set, the reenforcing bars are placed in position, the concrete is mixed, hoisted, dumped and packed between the forms, and allowed to set.

On the next morning the nuts connecting the sections of the outer forms are loosened, the steel wedges fixing the sections of the inner forms are lifted, and both inner and outer forms swing free from the wall. Then by means of the jacks resting on the widely flanged base collar, the whole mechanism is lifted until in position for a new fill and the forms again are set by means of the bolts and the wedges.

The actual raising of the forms for a new fill does not require more than ten minutes. Though some POLK SYSTEM contractors have successfully placed two fills a day during hot, dry weather, one fill a day is the most satisfactory rate of progress.

Advantages The POLK SYSTEM machine automatically keeps the wall of regular thickness, true to a circle and perfectly plumb. It does away with an always risky system of scaffolding and allows no strain on the "green wall." It is especially adapted for high work. It also provides a rapid and economical means of hoisting and depositing concrete in the form. Besides all of this the contractor can, with the standard POLK SYSTEM machine, build any sort of circular reenforced concrete work, such as grain storage bins, coal pockets, smoke stacks and water tanks, besides the silos that the farmers are calling for.

Testimonial Knoxville, Tenn., Jan. 16th, 1915.

Polk-Genung-Polk Co., Ft. Branch, Indiana.

Gentlemen:—In answer to your letter of the 11th inst. I am very willing indeed to advise you concerning my experience with the POLK SYSTEM.

The three Polk System machines bought June 1, 1914, ran steadily the remainder of the season and netted me a splendid profit. I attribute no little of my success to the certainty with which your machines do their work. Actual construction costs, after applying your schedule to local conditions, ran close with my schedule—so I know just "where I was" all the time. The depreciation on my equipment was negligible. My one best job was a concrete water tower 124 ft. high which I built with one of my Polk System machines.

This year inquiries for silos are coming so fast I am quite sure the demand will be greater than I can supply with three machines and will have to buy more machines. I can plainly see that this permanent silo business offers big opportunity for contractors and I am glad I adopted the "line."

Yours truly,

J. A. HIGGS.

Warranty The POLK SYSTEM machine is made of the best material obtainable and by the most skillful mechanics in the business. Every single part of the machine is tested before leaving the factory. The POLK SYSTEM machine is warranted to stand up to the hardest handling without breakage of any kind. The entire resources of the POLK SYSTEM and the whole POLK SYSTEM reputation stand back of every single POLK SYSTEM machine.

If there are points about the POLK SYSTEM that are not clear in your mind, kindly allow us to clarify them. If you want more complete information, if you want to know what our contractors are accomplishing, told in the words of the contractors themselves, we shall gladly furnish such information and such testimonials at your request. Prices will be furnished for delivery to any railway point in the United States, Canada or Mexico, or to any port for export trade.

The Hurst Silo

Patented 1902, 1904, 1914

THE CHAS. B. HURST COMPANY

Established 1904

819-829 Exchange Ave., Union Stock Yards

CHICAGO, ILL.

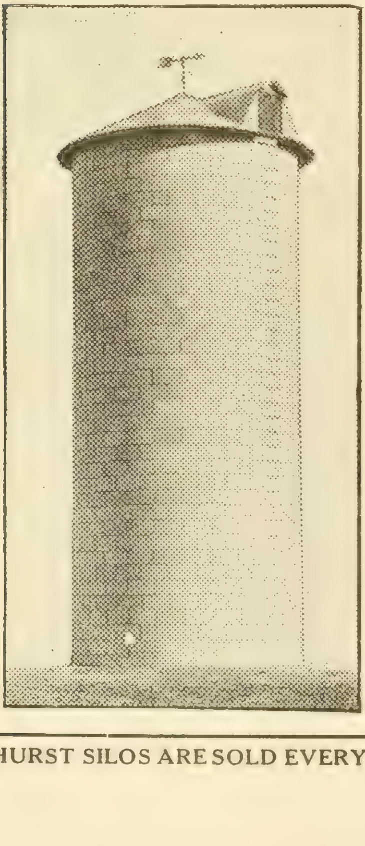
Chillicothe, O. Live Stock Exchange Bldg., Kansas City, Mo

Product We are the owners of the Hurst Reinforced Concrete Block Silo Patents and sole distributors of Hurst Patent Gravity Mass Block Molds for casting these Hurst Silo Blocks.

Description

The Silo

Hurst Silos are built of reinforced concrete blocks made in Hurst Patent Molds using the poured system. The Blocks are 23¾ inches long, 11¾ inches high and 4 inches thick; are dense, waterproof and have tremendous crushing resistance. Each block has running through it two steel rods ⅜ inches thick. These rods have their ends out turned at right angles in recesses in the ends of the block, as shown in Figure 3, No. 10. They are curved to form a perfect circle in any desired circumference.



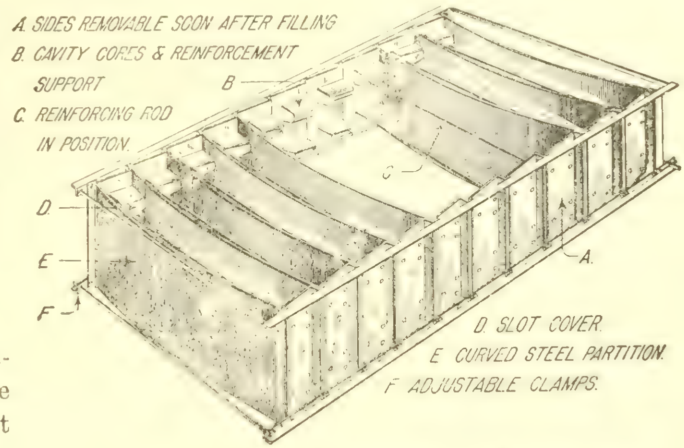
The blocks are laid in cement mortar same as any building block. The only difference is in the reinforcing and locking device. Each circle of blocks when laid in the wall forms a circular chain of which each block with its reinforcement is the long link. When blocks are set steel links are placed over the ends of the reinforcing bars, tension applied and then filled with cement. (See Figure 3, No. 10, and Figure 2.)

In the above manner Hurst Silos are erected. For closer detail see Figure 3. When walls are complete, a plaster ¼-inch thick of one part cement, two parts sand, one-fifth hydrated lime is applied, making a smooth, waterproof interior, which insures perfect settling and keeping of ensilage.

HURST SILOS ARE SOLD EVERYWHERE UNDER A WRITTEN GUARANTEE

Hurst Silo Molds Hurst Patented Gravity Mass Block Molds are furnished in sets of ten molds each, having a capacity of two hundred blocks per day. They are made of light steel of great strength and are practically indestructible. Each mold consists of two sides, two sets of division plates, clamps for locking molds, and core covers. The sides of the mold are of pressed steel, fitted with hollow pressed steel cores, which hold the reinforcing rods in position when the blocks are poured.

Each mold makes 10 blocks at one filling — full size or half blocks which are used at the doors.



Simple, Durable, Practical and Economical

Opportunity

The manufacture and sale of the Hurst Silo is a commercial proposition, and will enable you to work twelve months in the year, therefore, our proposition should interest you.

A small investment in equipment will take care of an immense amount of business, and insure quick returns.

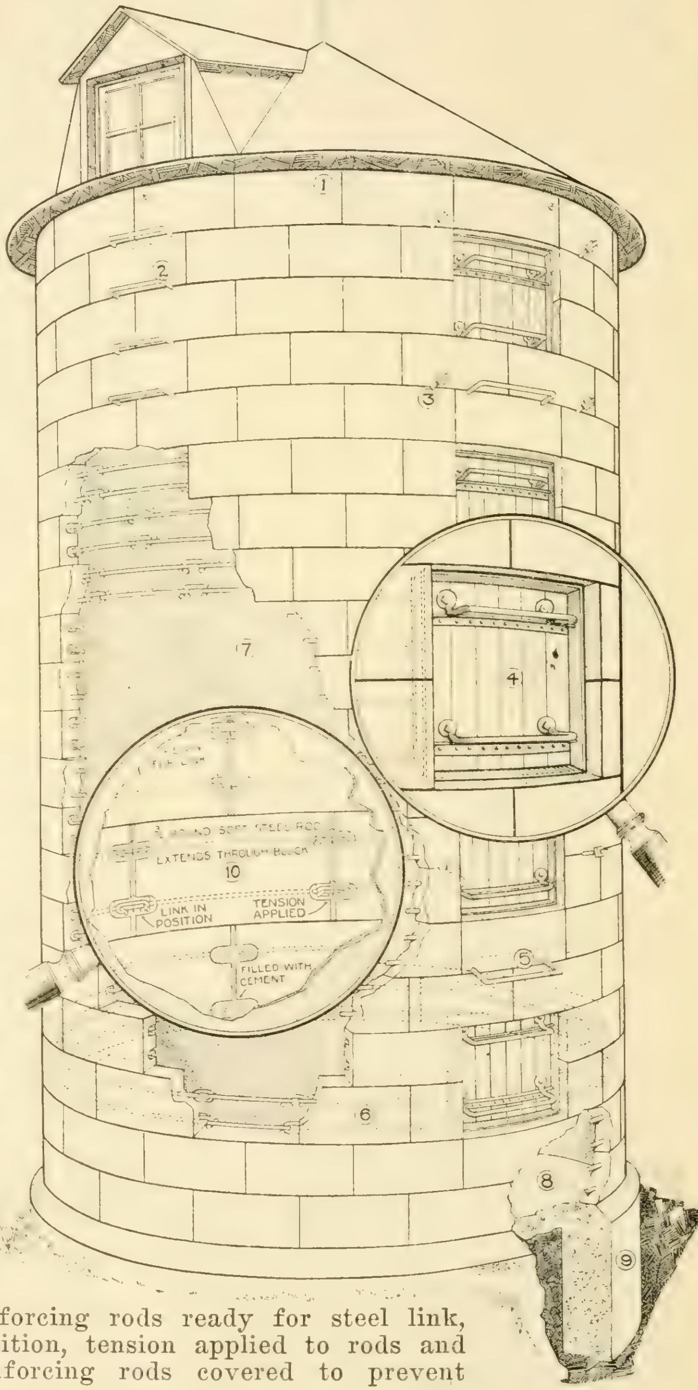
For more than eleven years Farmers and Stockmen have recognized the Hurst Silo as a safe investment and an ornament to the farm.

Eleven years and not a failure—That's the Record. The Hurst System of reinforced concrete construction reduces to the minimum time, labor, expense and competition.

We have some more openings for live, responsible parties, but they are going fast. Don't put it off, but act now. Write for particulars and catalog.

You Can Make Hurst Silo Blocks in the Dead of Winter

Operation



1—Bolt every 4 feet for fastening roof.

2—Step ladder.

3—Bolt every 3 feet for fastening chute.

4—Door, door frame, door ladder steps.

5—How ladder steps lay in mortar joints.

6—Reinforcing rods.

7—Sectional interior view showing reinforcing rods and links in blocks, also the smooth plaster finish wall on the interior.

8—Concrete floor. Hurst Silos can be built with or without this concrete bottom.

9—Foundation extending below frost line.

10—Shows reinforcing rods ready for steel link, link in position, tension applied to rods and finally reinforcing rods covered to prevent corrosion.

These Prominent Men and Institutions Use and Endorse Hurst Tanks and Silos

L. F. SWIFT
President, Swift & Co.
O. W. LEHMAN
The Fair Store, Chicago
THE ELMENDORF FARM
Lexington, Ky.
W. E. PINNEY
Banker, Valparaiso, Ind.
ILLINOIS STATE FAIR ASSOCIATION
Springfield, Ill.
M. W. SAVAGE
Owner of the Famous Dan Patch
NORTH OAKS STOCK FARM
Jas. J. Hill, Proprietor
P. W. CLIFORD
Railroad Contractor, Valparaiso, Ind.
CHARLES KELLY
Pres. National Live Stock Commission Co.
S. P. STEVENS
Sales Manager, Reid, Murdoch & Co.
JAMES BROWN
Head Buyer, Armour & Co.
M. WOLFE
Broker, Union Stock Yards, Chicago
W. H. LEAZENBY
Banker, Bethany, Mo.
L. B. COCKRELL
Banker, Winchester, Ky.
THOMAS JOHNSON
Pres. Lorain Coal & Dock Co., Columbus, O.
NORTHERN INDIANA LAND CO.
Demotte, Ind.
CAVE VALLEY LAND AND CATTLE CO.
Peoria, Ill.
THE POLK SANITARY MILK CO.
Indianapolis, Ind.
CALDWELL & SON
Burlington Jct., Mo.
B. C. RHOME
Pres. of North State Bank, Ft. Worth, Tex.
E. E. BETTS
Supt. Transportation, C. & N. W. R. R.
G. A. STEPHENS
Pres. Moline Plow Co.
C. D. THOMPSON
Trenton, Mo.

It Will Cost You Nothing To Investigate.

Reichert's standard molds have been successfully operated on structures varying from 6 ft. 0 in. to 40 ft. 0 in. in diameter; from 2 ft. to 85 ft. in height, and wall thickness, varying from 3 in. to 18 in.

The same unit mold since 1905. This record means—the endurance of an idea, the permanent satisfaction of a definite design.

OPPORTUNITY:

Stop and consider what one Reichert Adjustable Equipment can do. Some farmers need big silos, others want them made smaller. With a Reichert outfit you can satisfy them all with no extra outlay. One equipment does it all.

TESTIMONIAL:

Ballinger, Texas, May 19, 1915.

* * * I am having great success with my forms, building six feet easily on a twenty-foot silo, each day.

Silo building is taking a boom in the county and I have all I can possibly do.

Respectfully,

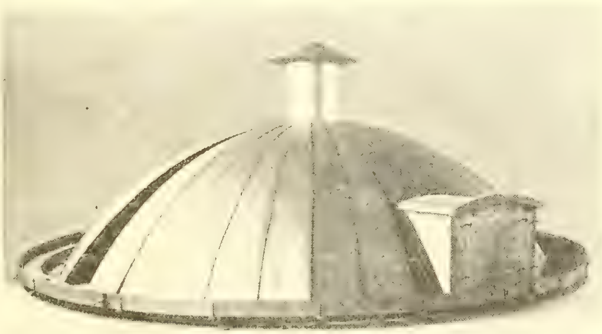
Chas. Eisenhuth.

ROOF MOLD:

The dome roof is the most unique design of any style of roof ever placed on a concrete silo. The Reichert Roof Mold consists of curved segments which rest on the silo wall and are locked to a hub, or ring, at the top. The angles of the separate sections fit into this hub, or ring, thus locking the entire equipment together. The segments of the roof can be packed closely together and loaded in a small space in moving from one job to another. The roof molds include the complete cornice mold and a mold for a dormer window.

REMARKS:

We are willing to go further than merely sending you our literature, prices, etc. We will gladly show you the operation of these molds right on the job or in our factory. Once seen, you'll have none others but the Reichert.

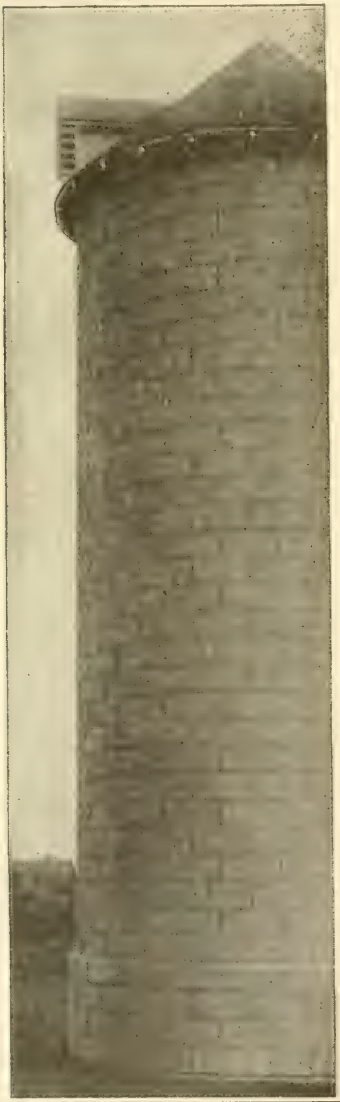


Perfect Reinforced Silo Block

Perfect Reinforced Cement Silo & Cistern Co., Delaware, O.

PERFECT SILO BLOCKS are shaped to the radius of the silo, and are 24 inches long, 12 inches high and 4 inches thick. The blocks lay up large, reducing the cost of laying, while on account of the thin wall they are not too heavy to handle.

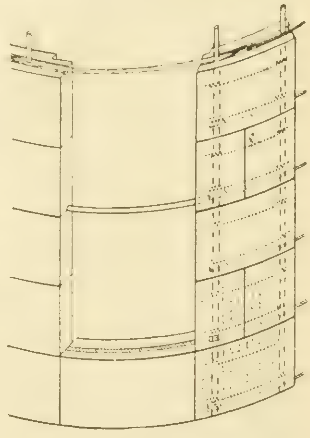
Each block is reinforced with two iron rods running lengthwise, 6 inches apart. Each rod is looped 6 inches from the end. These loops in the rod coincide with the holes that are formed edgewise through the block 1 inch in diameter and 6 inches from either end. In laying the blocks these 1-inch openings are filled with cement grout and a rod or dowel pin is pressed through the soft cement, connecting the two blocks. Each pin is inserted in such a way that it passes entirely through one block and half way through the block above and the one below.



This provides for a continuous lateral reinforcement around the silo every 6 inches, and the dowel pins that run through the blocks from the bottom to the top of the silo form a vertical reinforcement every 12 inches.

A strip of netting composed of 7 longitudinal and 12 vertical steel wires, imbedded in the block just beneath the outer surface, is designed to prevent any liability of cracking of the face of the block. This virtually forms a steel covering in the block near the outer surface of the entire silo.

To unite the blocks and to overcome the outward pressure or thrust, a two-ply twisted steel cable of No. 8 wire is laid outside of the dowel pins in the mortar between the courses of blocks, in grooves provided for that purpose. The ends of these cables are looped about a continuous gas pipe which extends from the top to the bottom of the structure, through the blocks each side of the doorway. This gas pipe also passes through holes in the ends of the ladder rounds thus the cable and the ladder rungs in connection with the gas pipe form a complete reinforcement around the silo from the top to the bottom, throughout each foot of its height, which reinforcement is four times more than sufficient to withstand the pressure of the ensilage, but it is so made in order to withstand the heat of a possible fire.



This illustration shows the continuous doorway with ladder rungs across same every alternate course of blocks, and the manner of connecting the ladder rungs and the twisted steel cable by means of the continuous gas pipe passing through the dowel pin holes in the blocks each side of doorway. It also shows the rabbet formed in the edge of the doorway blocks to receive the doors. The dotted lines at the right indicate positions of gas pipe, dowel pins, cable, netting and loop wires.

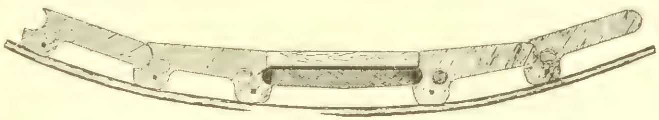
"Perfect" Silos Are Never Adversely Criticizde

Playford Stave Silos

Playford Mfg. Co., Inc. - - - Elgin, Illinois

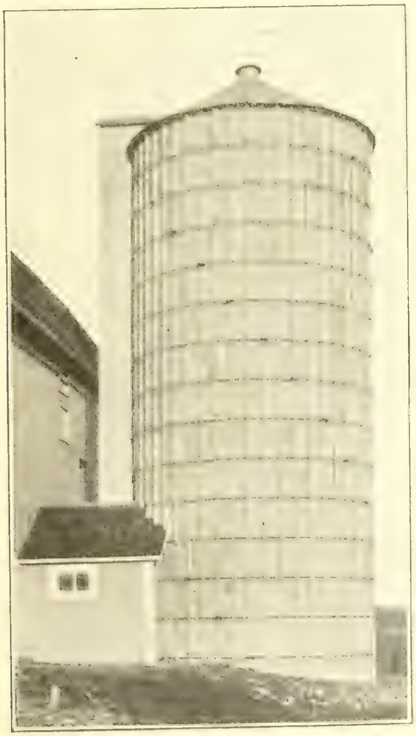
Those who live in the states of Minnesota, North and South Dakota, Iowa, Nebraska and Wisconsin, and wish to acquire an agency or manufacturing and sales rights in same, address the MINNESOTA CEMENT CONSTRUCTION CO., LONG PRAIRIE, MINN.

PRODUCT—A reinforced, ribbed, slushed concrete stave silo of great strength and matchless durability and efficiency.



End View of Staves, Showing Off-set Hoops and Form of Construction and Recess for Pointing Outside.

DESCRIPTION — The staves are slush molded in special molds. Each stave is thoroughly reinforced with bars. Each stave has a 4¼ rib that adds still greater strength. Each stave has a concave and convex edge and a lock on the ends. The staves interlock when erecting. The Playford staves are five times stronger than the ordinary stave. Absolutely waterproof. Outside pointing prevents the staves from "checking" and relieves the strain on the staves, thereby making it unnecessary to double-hoop. Hoops can't sag. The Playford Silo embodies the latest, up-to-date knowledge and experience in silo building. Being a new silo, we are not forced to cling to old ideas. We produce a silo that is strikingly different. The Playford will enable you as a contractor to offer an A No. 1 business proposition to the farmer.



OUR PROPOSITION—Be the contractor who will be able to give the farmer a real business proposition. The demand already exists—trade will come to you easily and quickly. There is 12 solid years of silo experience behind our proposition. We have plenty of capital and the equipment to "make good" in every direction. It's the broadest and most workable kind of a deal ever put out. Now is the chance to secure the choicest territory. Write to-day.

Playford Cement Stave Silo

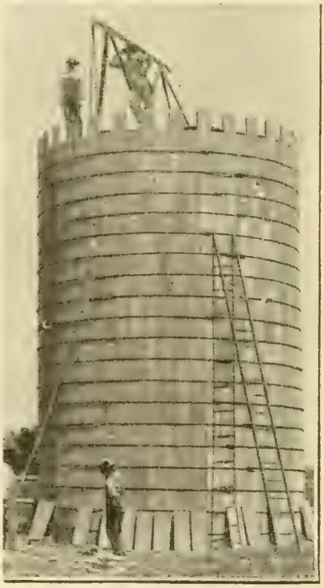
Cement Stave Silo Company Des Moines, Ia.

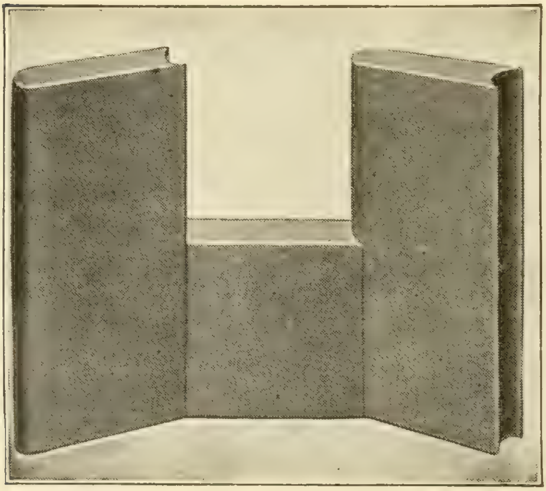
Patentees and Manufacturers

Product A system of erecting silos of cement staves which enables you to build them in any diameter and height at a lower cost than any other permanent silo, and a system for making the cement staves.

Description The machine for making the cement staves is on the order of a block machine, is portable and is operated with the same ease. This machine builds staves 30 inches long, 10 inches wide, 2½ inches thick with concave and convex edges that make perfect socket joints.

In construction the PLAYFORD CEMENT STAVES are put up vertically, interlocking at the half, with joints hermetically sealed and reinforced every 15 inches with steel hoops on the outside. This makes a smooth, thin, rigid, airtight and strong enough wall to withstand load and storm pressures, and frost. Open joints are allowed every 10 inches for expansion and contraction to eliminate cracked walls from heat or frost.





Advantages With the PLAYFORD CEMENT STAVE you do not limit your operations to silos only. Water tanks, utility houses, culverts and even straight-wall barns are built with these staves. Don't you see your opportunity here?

Opportunity Here's your chance to make money. Better write us for particulars and terms on our STAVE MACHINES.

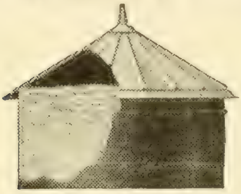
Playford Cement Stave Silo is the King of Silos—Ask the farmer

Hoosier Silo Extension Roof

AND METAL CHUTE

Sheet Metal Specialty Co. **Goshen, Ind.**
Manufacturers

Product A metal silo roof which can be opened up out of the way, when filling the silo, and when so opened forms an extension to the top of the silo, which takes care of the settling of ensilage.



Roof Closed

Description The roof consists of three parts: a base, a double section segment and a single section segment. The base is fastened to the silo by means of strap irons. The segments are made of crimped galvanized sheet metal and both single and double section segments are hinged alternately to the base. The double section segments have two wings hinged on each side, which fold one inward and the other outward. When opened and locked they form a complete circle, like shown in illustration.

Advantages The farmer once shown will see these points in favor of a HOOSIER roof:

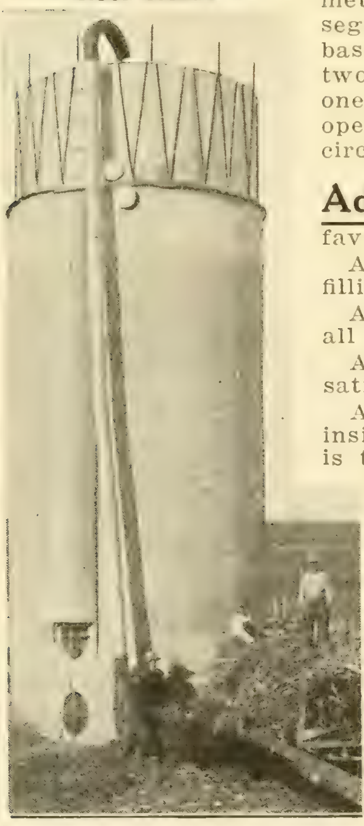
A roof that is not in the way when filling the silo.

A roof that makes it possible to use all your silo.

A roof that will fit any silo and work satisfactorily.

A roof that measures the same on the inside as your silo, therefore, the silage is the same volume as that in your silo.

A roof that is void of cross arms and braces to hinder your silage from settling.



Roof Open

Remarks The HOOSIER SILO EXTENSION ROOF will help cinch the sale of a silo. Just try it on the next farmer and see how interested he'll become. Only men like him will appreciate the value of this roof, because you give him more for his money.

Better get posted on this HOOSIER SILO EXTENSION ROOF, Mr. Concrete Silo Builder. It will help you wonderfully in your business. Ask for our catalogue.

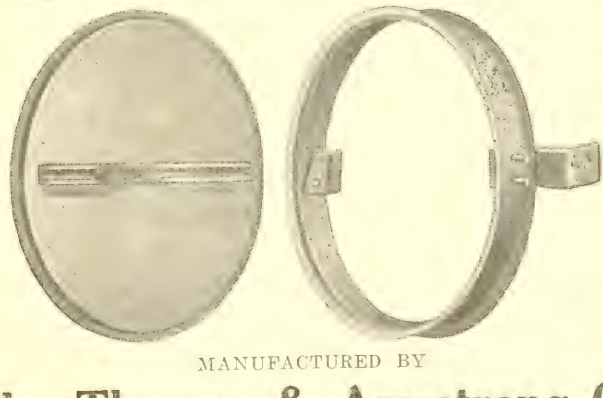
The HOOSIER Roof is not only right in theory but Guaranteed Practical

Buckeye Silo Roofs

Gambrel Roof With Dormer Window.

We manufacture a full line of sheet metal equipment for concrete silo, such as Gambrel, Third Pitch and Extension Roofs. Also Metal Chutes, Ladders and Ladder Rungs.

Buckeye All Steel Silo Door For Concrete Silos



MANUFACTURED BY

The Thomas & Armstrong Co.

London, Ohio

For sale by

B. L. BEVINGTON MCH. CO.

549 W. Washington Blvd. CHICAGO, ILLINOIS

—AND—

THE PIERCE CO.

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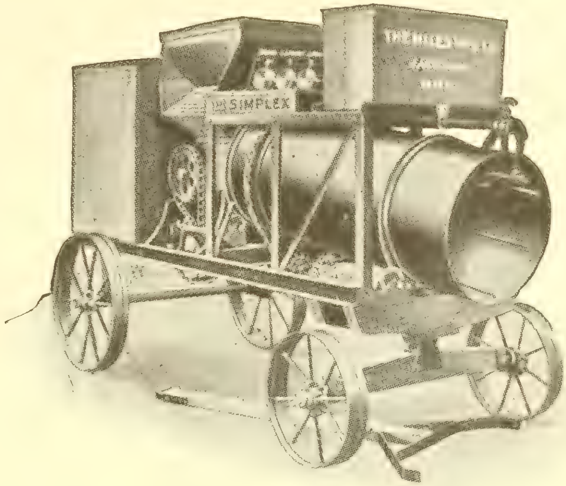
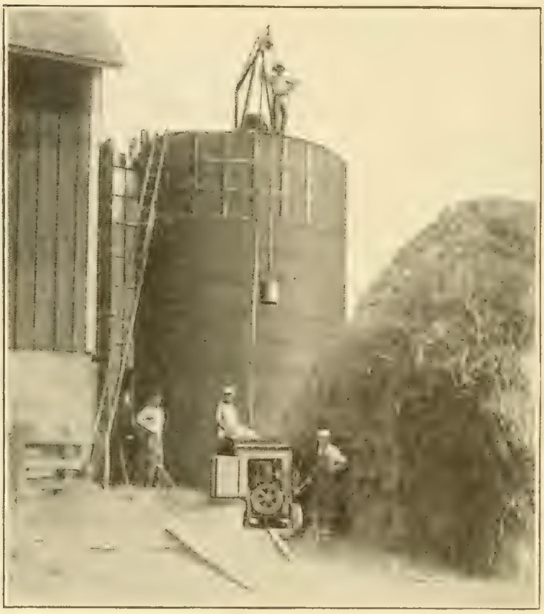

SIMPLEX

A Baby Grand on Silo Work

A Continuous Mixer and a Single Drum Hoist Combined

HALL-HOLMES MFG. CO.

509 OAK STREET **JACKSON, MICH.**

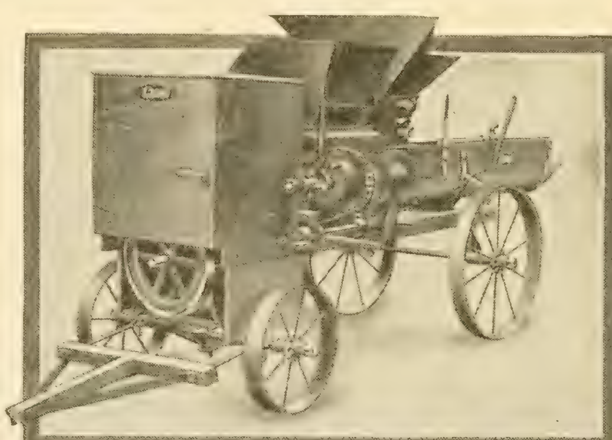


Operation The illustration gives a fair idea of the operation of a Baby Grand Mixer, with Single Hoist Drum, used on a silo job. The contractors are Arnold Nagel & Co., Libertyville, Ill.

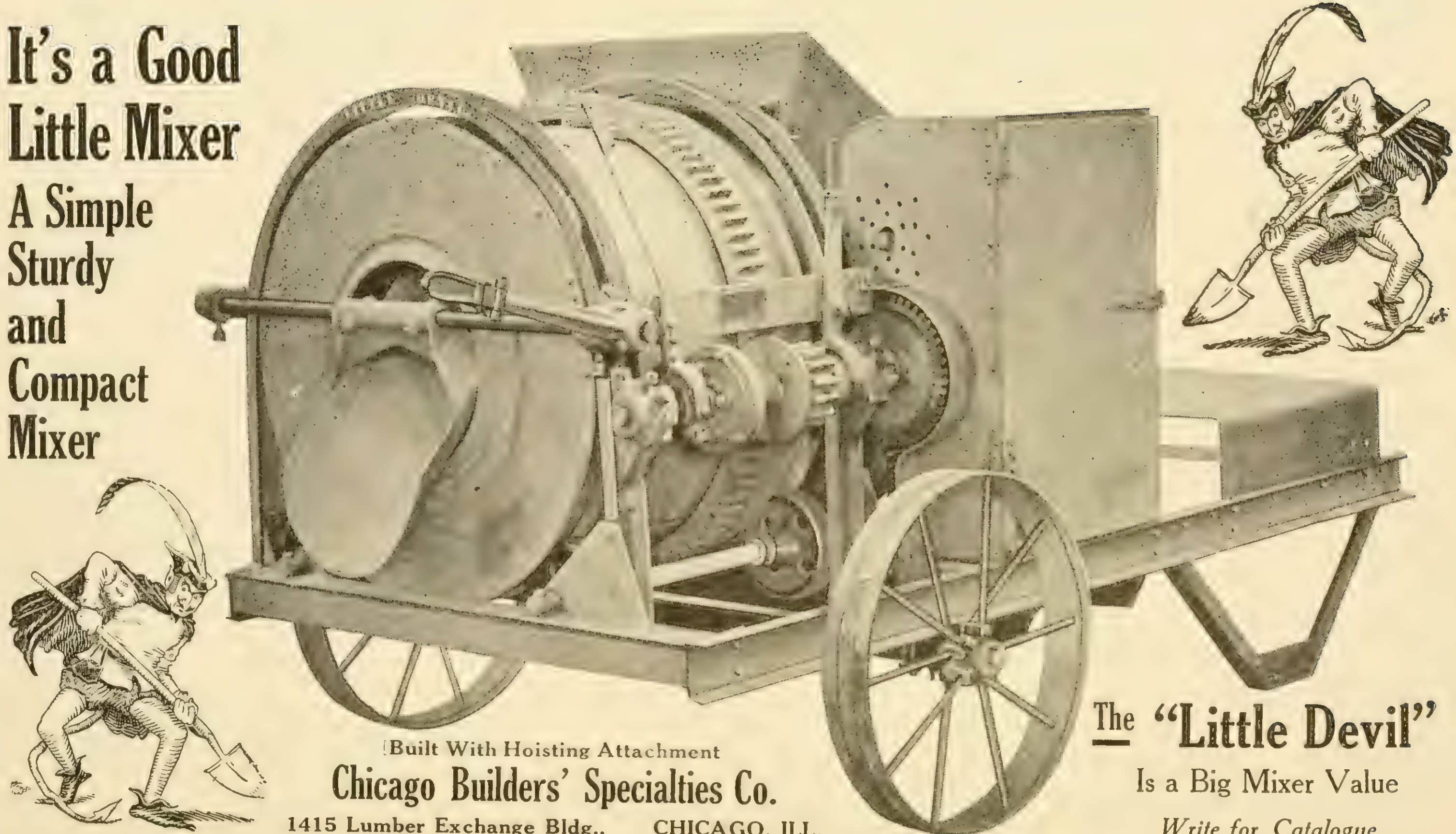
Description The Baby Grand Mixer is universally recognized as the best continuous concrete mixer for all purposes. It eliminates uncertainty. The first batch is the same as the last. It is built for hard service and the cost of upkeep is practically nothing All working parts are completely enclosed in steel housing to protect them from grit and dirt.

Facilities If you are building a silo or a concrete floor in the upper story of a building, a hoist on your continuous mixer enables you to pour a steady stream of concrete. The hoist is mounted on the frame of the machine and operates with or independent of the mixer.

Testimonial "The hoist I bought for my Baby Grand has given perfect satisfaction. Yours respectfully, J. L. Irving." General contractor and builder of Area, Lake County, Illinois.



ASK FOR CATALOG


It's a Good
Little Mixer
A Simple
Sturdy
and
Compact
Mixer
The "Little Devil"
Is a Big Mixer Value
Write for Catalogue
Built With Hoisting Attachment
Chicago Builders' Specialties Co.
1415 Lumber Exchange Bldg., CHICAGO, ILL.